HARVARD BUSINESS STUDIES

VOLUME I

SCIENTIFIC MANAGEMENT

A COLLECTION OF THE
MORE SIGNIFICANT ARTICLES DESCRIBING
THE TAYLOR SYSTEM OF MANAGEMENT

EDITED BY

CLARENCE BERTRAND THOMPSON, LL.B., A.M.
LECTURER ON MANUFACTURING IN HARVARD UNIVERSITY

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PREFACE

THE Taylor system of industrial organization, to which the name "Scientific Management" has been applied and by which it is generally known, has become a subject of intense interest to business men and students of management. During the past fifteen years the movement has been developing a fairly extensive literature. Fortunately the main authorities — the classics on the subject — are easily available: Taylor's *Shop Management*, *Principles of Scientific Management*, *Art of Cutting Metals*, and Gantt's *Work, Wages and Profits*. A thorough mastery of these is indispensable to a real knowledge of Scientific Management.

There is a wide-spread demand, however, for more detailed information regarding certain phases of Scientific Management than is given in these books. "Practical men" want to know exactly what is meant by such phrases as "elementary time study" and "functional foremanship." They want to know also how the system has actually worked in the industries to which it has been applied. Thorough students of industrial development wish to know more of the theory underlying this latest type of organization. The public at large is interested in the social and economic bearings of the movement, particularly in its favorable effect on the welfare of the laboring classes and, through them, of the community as a whole.

Something of value has been published on all these subjects. It is scattered, however, through many magazines and official reports and in books on other subjects. Much of it is either out of print or in technical periodicals difficult of access to the layman.

It is the editor's aim to bring together in this volume the best (in some cases the only) articles available to meet the varied demands enumerated above. The variety of the demand accounts for the variety of the offering. Editorial effort has been applied to the selection of material, condensation where practicable, and comment only when necessary for fuller understanding or for correction of errors of fact or theory. The result, it is hoped, is a useful supplement to the standard works of Taylor and Gantt referred to above.

It remains but to render grateful acknowledgment to the authors and publishers to whom detailed credit is given in the body of this book, and to Edwin F. Gay, Dean of the Graduate School of Business Administration of Harvard University, without whose stimulus and encouragement the editor would probably never have found the time to finish this task.

C. BERTRAND THOMPSON.

BOSTON, MASS., August, 1914.

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THE LITERATURE OF SCIENTIFIC MANAGEMENT

By C. BERTRAND THOMPSON

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Any discussion of the literature of scientific management is confronted at the outset with the question, What is scientific management ? The development of the factory system brought with it many new problems connected with the organization and management of labor, the structure and equipment of factories, and the technique of production. By successful manufacturers these problems have always been solved in a way to make manufacturing at a profit possible. Early solutions, however, were necessarily crude and roughshod. With the enormous increase in demand for manufactured products, in the investment of capital, and in the number of men engaged in the business, with the consequent development of ever-keener competition, the early methods have been found insufficient. Especially within the last twenty years a degree of skill and technical training has been brought to bear upon the solution of factory problems which has made modern factory management a thing much more elaborate, refined, and effective than ever before. A series of improvements in administration and methods have been made by many engineers and managers, and not a few of them have been developed by a method which might truly be called scientific. Where, then, can we draw the line between modern management in general and what has come to be known technically as " scientific management " ?

Out of the mass of engineers and managers who are responsible for present-day methods, there has grown a group originating with Mr. Frederick W. Taylor of Philadelphia, who have perceived certain principles underlying the practices of management hitherto unrelated and uncoördinated. A collation of isolated successful experiments in various details of factory administration and methods has apparently shown a possibility of classification and generalization. Such classification and generalization are the basis for the development of a science, and the term "scientific management" is applied generally to the body of principles deduced from experience by Mr. Taylor, and the engineers associated with and trained by him, and to the methods by which the resultant principles are applied to industry. "Scientific management," therefore, is distinctively scientific, since it aims to correlate and systematize all the best of modern developments in factory administration, and to push development further in accordance with the principles discovered.[1]

On the basis of this definition it is not difficult to select that portion of the large current literature of factory management which deals with scientific management from that other portion which describes and outlines the many unrelated improvements, methods, and principles which are continually being evolved. The literature of scientific management as such is that which has been published by those who approach the subject in a scientific manner. Of these Mr. Taylor is the acknowledged pioneer and leader both in practice and theory.[2]

The literature of scientific management is found in a few books written by practitioners of the science, a few official reports growing out of disputes as to railroad rates and labor difficulties, technical articles which have appeared in the transactions of engineering societies and in engineering and other technical magazines, and a considerable mass of "popular" articles written to satisfy the recent wide-spread interest in the subject.

These books and articles may be classified, for the purposes of the present review, in six groups.

[1] Mr. Charles B. Going has published an article, "The Efficiency Movement — an Outline," *Transactions*, The Efficiency Society, vol. 1, p. 11, showing the place of scientific management in the modern developments of factory organization and pointing out the common element in many movements.

[2] With the possible sporadic exception of Charles Babbage, whose book, *The Economy of Manufactures*, was published in 1832, fifty years ahead of its time.

The first group includes those incidental to or dealing with the development and theory of scientific management as a whole. It consists of the original publications of the pioneers and such popular statements as reveal a clear grasp of the movement.[1]

The second group includes descriptions of scientific management in operation, written as a rule by managers of plants which have developed the system.

As a result of the injection of scientific management into the discussion of railroad rates, there has arisen a considerable body of literature on the possibility of the application of the system to railroads. This is of sufficient consequence to constitute the third class.

In the fourth class are the many detailed descriptions of methods which are either distinctive of scientific management, or, though not peculiar to scientific management, coördinated and assimilated by it into its own system.

Those methods of scientific management which affect most directly the human factor in production have stimulated a literature which is of sufficient importance to warrant being put into a fifth class by itself.

In the sixth and last group is the series of discussions dealing with the relation of scientific management to organized labor.

The more important books and articles are discussed briefly in the text. Others not sufficiently distinctive or noteworthy to call for special review, but important for students of the movement, are referred to in the notes. The text and notes together cover nearly ninety per cent of all that has been published on the subject in English.[2]

1. Development and Theory of Scientific Management as a Whole

In 1832, Charles Babbage, the eminent mathematician, published a book[3] in which he attempted to deduce from the practice

[1] Many of the popular articles are evident pot-boilers, too ill-considered and ephemeral to be worthy of discussion and preservation.

[2] Practically everything of any consequence is included in the bibliography at the end of this volume.

[3] *The Economy of Manufactures.* Chas. Knight, London, 1832. (Out of print.)

of manufacturing as it existed in his time, the general underlying principles which apparently controlled it. This piece of work, though crude in the light of modern advance, was so far ahead of the state of contemporary manufacturing intelligence that its significance was entirely overlooked, and it is only today that the force of his analysis is evident. Although it does not appear that the modern group of scientific managers are in the slightest degree indebted to Babbage's work, it is interesting to observe in it the suggestion of the extension of specialization beyond manual labor to mental labor, which is at the basis of the Taylor doctrines of functional foremanship and the separation of planning from execution. Babbage also foreshadows the use of timing as an aid in the development of processes; but in this he was not so fortunate, and the undeveloped method he used is not even remotely connected with modern time study.

The important stimulus to the modern development is found in the work of a group of managers and engineers, members of the American Society of Mechanical Engineers, who drew the attention of their fellow-members to the influence of wages on the output of workmen. The earliest of these was Mr. Henry R. Towne, president of the Yale & Towne Manufacturing Company. Mr. Towne has always been essentially a thinker in industry. Early in the eighties he wrote a paper [1] which was a plea for the technically trained engineer to concern himself in the financial and profit making aspects of management — to be an "economist" because he effects economies. As a result of taking his own advice in his own plant, and after a realization of the practical inefficiency of profit sharing as an incentive to production, Mr. Towne evolved [2] and described a modified type of profit sharing which he called "Gain Sharing." It consisted in modifying profit sharing by applying it to departments instead of to the business as a whole, and basing it upon demonstrable gains in the efficiency of departments as evidenced by careful accounting.

[1] "The Engineer as Economist," *Transactions*, American Society of Mechanical Engineers, vol. 7, p. 425. These transactions will be abbreviated hereafter *Trans. A. S. M. E.*

[2] "Gain Sharing," *Trans. A. S. M. E.*, vol. 10, p. 600.

Out of the discussion of this paper grew practically the entire modern literature on wage systems as incentives.

Prominent on this subject were the papers of Mr. F. A. Halsey and Mr. James Rowan [1] and an article by Mr. Rowan.[2] The object in the mind of these managers was to provide a definite basis on which gains in efficiency could be measured, and to bring the gain and the consequent bonus home to the individual workman. It was an attempt to remedy the defects both of profit sharing with its indefiniteness and of piece rates with their temptation to cutting; and it amounts practically to the rough determination of a standard of individual performance and the announcement in advance of a systematically graded and expected cut.

While this discussion (the very considerable literature of which is outside the scope of this paper) was in progress, Mr. Frederick W. Taylor, an engineer of Philadelphia, who had become foreman and master-mechanic of the Midvale Steel Company, was trying to solve the problem of individual and plant efficiency by another and an essentially different method. One result of his experiments was the development of a new form of piece rate now known as the "differential piece rate," according to which a workman is paid a low rate per piece for ordinary production and a considerably higher rate for production according to a standard, determined by careful and accurate time study, and made possible of attainment by systematic training of the workman and by such management of the plant as facilitates to the utmost the operations performed by the laborer. Mr. Taylor's first statement of his methods and results was submitted to the American Society of Mechanical Engineers in a paper [3] which has been described by Mr. Going, the accomplished editor of the *Engineering Magazine*, as "one of the most valuable contributions that have ever been made to technical literature."

[1] "The Premium Plan of Paying for Labor," *Trans. A. S. M. E.*, vol. 12, p. 755. Reprinted in *Sibley Journal of Engineering*, vol. 16, p. 219, and in *Trade Unionism and Labor Problems*, chap. xi, edited by John R. Commons. Boston, 1905.

[2] "A Premium System applied to Engineering Workshops," *Proceedings*, Institute of Mechanical Engineers, March 20, 1903, p. 203.

[3] "A Piece Rate System," *Trans. A. S. M. E.*, vol. 16, p. 856; reproduced in this volume, p. 636.

At this stage of the development, the system consisted of " three principal elements: (1) an elementary rate fixing department, (2) differential rate system of piece work, (3) what he (Mr. Taylor) believes to be the best method of managing men who work by the day." The rate fixing department analyzes and standardizes work and piece rates with the aid of elementary time study. This procedure differs from that of other rate fixing departments " in that a careful study is made of the time required to do each of the many elementary operations into which the manufacturing of an establishment may be analyzed or divided. These elementary operations are then classified, recorded, and indexed and when a piece work price is wanted for work, the job is first divided into its elementary operations, the time required to do each elementary operation is found from the records, and the total time for the job is summed up from these data."

The differential rate system of piece work is defined briefly as " offering two different rates for the same job, a higher price per piece in case the work is finished in the shortest possible time and in perfect condition, and a low price if it takes a longer time to do the job, or if there are any imperfections in the work (the high rate should be such that the workman can earn more per day than is usually paid in similar establishments)." The best method of managing men who work by the day " consists of paying *men* and not *positions*. Each man's wages as far as possible are fixed according to the skill and energy with which he performs his work, and not according to the position which he fills. Every endeavor is made to stimulate each man's personal ambition." The advantages of this system as deduced by Mr. Taylor from ten years' experience with the Midvale Steel Company are: first, lower cost of production with, at the same time, higher wages; second, by substituting knowledge for guess work, the elimination of the motive for " soldiering "; third, the substitution of exact knowledge leads to a treatment of the men with greater uniformity and justice, and their response with more and better work; fourth, coöperation of the men and the management is made obviously their common interest; fifth, the system is rapid in attaining the maximum productivity, which is automatically maintained by the differential rate; sixth, it selects and attracts the best men, develops many slow and inaccurate workmen into first class men, and discourages and sifts out men who are incurably lazy or inferior; seventh, " it promotes a most friendly feeling between the men and their employers, and so renders labor unions and strikes unnecessary."

The paper then proceeds to discuss the Towne and Halsey wage systems and profit sharing, and points out the absence in all of them of a definite measure of a day's work. It then describes the method of elementary rate fixing and the application of the differential piece rate by its means, with illustrations of the results attained.

It is significant of Mr. Taylor's habit of mind that this early paper is a description of methods and results, including hardly a suspicion of theoretical deduction. It is a testimony to the accuracy of Mr. Taylor's later statement that scientific management is not a theory to be applied to practice, but that it is first and primarily a practice out of which, many years after its beginning, a theory has developed.[1]

The difficulty of bringing a plant to the necessary perfected degree of administration and the apparent severity of the differential piece rate led one of Mr. Taylor's collaborators, Mr. H. L. Gantt, to develop a different form of premium system, which retained, however, the essential element of an accurate time study basis. This method, known as the " Gantt bonus plan," is a time rate method. It guarantees the operator the regular hourly or daily rate but adds a bonus for achievement of the standard quantity and quality of work, known as " the task." This standard is set, as with Mr. Taylor's differential piece rate, by time study. Mr. Gantt has published a large number of articles on the subject, the best of which, together with his own

[1] An interesting description of the application of this form of piece rate is found in " The Taylor Differential Piece Rate System, " *The Engineering Magazine*, vol. 20, p. 617, by Mr. Sanford E. Thompson, one of the early collaborators with Mr. Taylor and a recognized expert on time study. A good discussion of the whole matter grew out of a weak paper by Mr. F. Richards, " Is Anything the Matter with Piece Work ? " *Trans. A. S. M. E.*, vol. 25, p. 68, participated in by Mr. Taylor, Mr. Emerson, and others.

development of the relation of scientific management to some of the human problems involved, have been collected in one volume.[1]

Mr. Gantt points out how by the ordinary methods of management the cost of production, which is at the basis of the great problem of the increasing cost of living, follows a vicious circle of higher wages to meet higher cost and increased cost as the result of higher wages. The way out is to manage production in such a way that higher wages bring a decreased cost; and this is the aim of scientific management. This is accomplished by standardizing the conditions for efficient operation, instructing the workmen thoroughly in the best methods, and using wages as an inducement to them to accept the instruction and the conditions provided. The development of the Gantt bonus and its relation to piece work are described in detail, and the effect of the system on the workman's habits of industry and coöperation is outlined and demonstrated with charts and diagrams showing comparisons between old methods and the new. These charts, based upon the records of actual workers, are extraordinarily interesting human documents, showing the gradual overcoming of difficulties and the fixation of habits of punctuality, reliability, and efficiency. The 1913 edition adds a chapter to the effect that, as the great natural resources of this country can be relied on less and less in competition with other countries, our future depends upon the application of scientific methods and the increase in the efficiency of operation, and concludes with a brief chapter illustrating some of the detailed methods of the Taylor system as developed by Mr. Gantt.

This book of Mr. Gantt's is one of the best that has appeared on the subject and is entitled to rank with Mr. Taylor's *Shop Management* and *The Principles of Scientific Management*, as one of the standard authorities.

Scientific management, however, is not merely a system of wage payment. One of its essential features is the determination and application of standards not only of performance, but of

[1] *Work, Wages and Profits*. Engineering Magazine Co., New York, 1910. The first edition, published in 1910, is somewhat enlarged and considerably revised in the second edition, 1913.

methods and equipment. In fact, it is a cardinal principle of scientific management that a proper standard of performance cannot be attained in the absence of standardized methods and equipment; and it was in the effort to secure standard performance that Mr. Taylor and his associates were led to investigations of detailed processes which have themselves become classics. One of the earliest of these is Mr. Taylor's "Notes on Belting," [1] which, with the later paper by Mr. Carl G. Barth,[2] has had an immense influence on the current manufacture and use of belts. Another investigation growing out of Mr. Taylor's work was concerned with the proper composition and method of heat treatment of tool steel, and the shape of cutting tools. This investigation, carried on with the assistance of Messrs. Gantt, Barth, and Maunsel White, and extending over twenty-six years, led incidentally to the discovery of high-speed steel, which has revolutionized machine shop practice and the design and construction of machine tools all over the world. The results of this investigation are published in Mr. Taylor's paper called "The Art of Cutting Metals." [3]

While Mr. Taylor was carrying forward in a variety of industries the development of his distinctive type of management, but was publishing nothing about its details,[4] Captain Henry Metcalf had been developing independently and describing [5] a system of

[1] *Trans. A. S. M. E.*, vol. 15, p. 204.

[2] "Transmission of Power by Leather Belting," *Trans. A. S. M. E.*, vol. 31, p. 39.

[3] *Trans. A. S. M. E.*, vol. 28, p. 31. The introduction and a part of the discussion of this paper are reproduced in this volume, p. 242. An interesting explanation of one of the means by which Mr. Taylor's results are applied in machine shop practice is found in the paper by Mr. Carl G. Barth, the mathematician of the group, on "Slide Rules as Part of the Taylor System," *Trans. A. S. M. E.*, vol. 25, p. 49. An illustration of the effect of such work as a stimulus to the application of thought to management appears in the article by Mr. Charles Day called "The Machine Shop Problem," *ibid.*, vol. 24, p. 1302, which emphasizes the need of coördination, analysis, and a scientific determination of facts.

[4] The only paper by a member of the Taylor group dealing with any detail was Mr. Gantt's "Graphical Daily Balance in Manufactures," *ibid.*, vol. 24, p. 1322, reproduced in this volume, page 420, which was a description of the method of scheduling introduced by him at the American Locomotive Works.

[5] "The Shop Order System of Accounts," *Trans. A. S. M. E.*, vol. 7, p. 440. *The Cost of Manufactures and the Administration of Workshops*, John Wiley & Sons. New York, 1885. 3d edition, 1907.

routing and accounting in the government arsenals, and Mr. Oberlin Smith, president of the Ferracute Machine Company, had presented an interesting paper on the naming of machine parts.[1] When the opportunity came Mr. Taylor helped himself freely to the suggestions in these papers and incorporated them, with considerable modification, into his practice.

Finally, after twenty years' experience, Mr. Taylor submitted to the American Society of Mechanical Engineers the history and methods of his system in what seemed to him to be definite, complete, and coördinated form. This was his famous paper on "Shop Management,"[2] which has been extensively reprinted and translated into French, German, Dutch, Italian, Russian, Lettish and Japanese. In response to the popular interest in the subject brought about by the railroad rate case in 1911, Mr. Taylor was induced to publish a less technical statement under the name *The Principles of Scientific Management.*[3]

"Shop Management" is a considerable expansion of the earlier paper on "A Piece Rate System," and includes much of the detailed methods that had been developed by Mr. Taylor in the intervening years, together with some analysis of the industrial and economic principles involved in his system. The emphasis is laid throughout on the importance of "the coupling of high wages for the workman with low labor cost for the employer," and the eventual interest of the public in the reduced prices resulting from this combination. The difference between the "first class man" and the average workman, the means for selecting or developing the former class, the methods of accurate scientific time study, the philosophy and operation of the task idea in management, the determination of standards, the separation of planning and execution, the development of functional foremanship and the planning department, and steps to be taken in chang-

[1] "The Naming of Machine Parts," *Trans. A. S. M. E.*, vol. 2, p. 366, reproduced in this volume, page 452.

[2] *Trans. A. S. M. E.*, vol. 24, p. 1337. New edition. Harper & Bros., New York, 1911.

[3] Harper and Bros., New York, 1911. A very brief résumé by Mr. Taylor, "Principles and Methods of Scientific Management," is found in the *Journal of Accountancy*, vol. 12, pp. 117, 181.

ing from ordinary to " the best type of management," are dealt with extensively. Emphasis is laid on the " evils of soldiering " and the failure of piece rates and premium plans to overcome them; it appears that Mr. Taylor's entire system grew out of his determination to break up this practice.

The objects sought can be attained, according to Mr. Taylor, most easily by the application of the following principles: —

(a) *A Large Daily Task.* — Each man in the establishment, high or low, should daily have a clearly defined task laid out before him. This task should not in the least degree be vague nor indefinite, but should be circumscribed carefully and completely, and should not be easy to accomplish.

(b) *Standard Conditions.* — Each man's task should call for a full day's work, and at the same time the workman should be given such standardized conditions and appliances as will enable him to accomplish his task with certainty.

(c) *High Pay for Success.* — He should be sure of large pay when he accomplishes his task.

(d) *Loss in Case of Failure.* — When he fails he should be sure that sooner or later he will be the loser by it.

When an establishment has reached an advanced state of organization, in many cases a fifth element should be added, namely: the task should be made so difficult that it can only be accomplished by a first class man.

The rest of the book is an amplification of the methods by which these so-called " principles " are applied.

The Principles of Scientific Management develops the same ideas in a slightly different way. Considerable emphasis is laid on the importance of the substitution of scientific knowledge and incentive on the part of the management for the old reliance on the crudely stimulated initiative of the workman. There is the same discussion of "soldiering," inadequacy of piece and premium systems, and a non-technical review of certain typical methods of the system, with illustrations of the application of scientific method to such diverse operations as shovelling, pig-iron handling, and the cutting of metals.

It is interesting to note in the later book a restatement of the " principles," otherwise referred to as " elements " ; —

First. The development of a true science. *Second.* The scientific selection of the workman. *Third.* His scientific education and development. *Fourth.* Intimate friendly coöperation between the management and the men.

In an earlier section of the same book, these "principles" are restated in slightly different form as the "new duties" devolving on the management. In this case they are given as follows: —

First. They develop a science for each element of a man's work, which replaces the old rule-of-thumb method.

Second. They scientifically select and then train, teach, and develop the workman, whereas in the past he chose his own work and trained himself as best he could.

Third. They heartily coöperate with the men so as to insure all of the work being done in accordance with the principles of the science which has been developed.

Fourth. There is an almost equal division of the work and the responsibility between the management and the workmen. The management take over all work for which they are better fitted than the workmen, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men.

It is evident from these statements that Mr. Taylor does not distinguish sharply between principles, duties, and methods, and it is difficult to see why the methods selected for elevation into the class of principles are limited to those given and do not include such fundamental and radical departures as functional foremanship and the task and bonus. This is but another evidence of the fact that the Taylor system is in reality the summation of years of the varied experience of many individuals, which has not even yet been thoroughly coördinated and developed into such a system of real principles or laws as characterizes other modern sciences. I believe that the principles are there and that they only await definite and systematic formulation.

In the summer of 1911, the unionized machinists and molders employed at the Watertown Arsenal, where the Taylor system was being developed by Mr. Carl G. Barth, walked out; and on being taken back petitioned that the Labor Committee of Congress investigate the subject and recommend such legislation as would be necessary to protect their interests. A Committee was appointed consisting of Mr. William B. Wilson, the present Secretary of Labor, Mr. William C. Redfield, now Secretary of Commerce, and Mr. John Q. Tilson, "to investigate the Taylor and other systems of management" in government shops. The investigators confined themselves practically to the Taylor system, held hearings at the principal navy yards, and took testimony of workmen, foremen, managers, " efficiency experts," and practically the entire group of Taylor system engineers. The result of their investigation was a brief report that no legislation was necessary. More useful, however, was the publication of the great mass of testimony taken.[1] This report of the hearings is a perfect mine of information in regard to the history, methods, practice, and results of the Taylor system and must be strongly recommended as one of the fundamental sources on the subject.

Another important body of testimony is that introduced by Mr. Louis D. Brandeis as part of the case of the shippers in the " Eastern Rate Case "[2] which is carefully sifted, analyzed and coördinated in Mr. Brandeis' brief.[3]

The most important publication of Mr. Taylor, in addition to those mentioned, is a book prepared by him and Mr. Sanford E. Thompson,[4] which includes, in addition to an acute analysis of concrete construction, certain chapters on time study and valuable tables of unit times determined in accordance with the Taylor methods.[5]

[1] *Hearings before the Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management.* Government Printing Office, Washington, 1912.

[2] *Interstate Commerce Commission Reports*, vol. 20, p. 243.

[3] A part of this brief was published under the title *Scientific Management and Railroads*, Engineering Magazine Co., New York, 1912. The testimony in this case had no effect on the decision of the Interstate Commerce Commission; but the spectacular and seemingly extravagant form in which some of the testimony was given by persons outside the Taylor group but influenced by it, caught the popular fancy and was responsible for the great publicity the movement suddenly attained.

[4] *Concrete Costs*, John Wiley and Sons. New York, 1912.

[5] Two interesting articles by Mr. Taylor, " Why Manufacturers Dislike College Graduates," *Sibley Journal of Engineering*, vol. 24, p. 196, and " A Comparison of University and Industrial Methods," *Stevens Indicator*, vol. 24, p. 37, set forth his convictions in regard to the place of college graduates in manufacturing and particularly his criticisms of their point of view and the handicaps under which they labor and for which their college training is responsible. Chief among these are the inability to concentrate on an undertaking and bring it through to a conclusion, the failure to recognize the importance of punctuality and the value of time and discipline, and a lack of appreciation of the point of view of the workingman.

There is an interesting comment on this in Mr. D. C. Jackson's " Criticism of the Engineering Schools," *Stevens Indicator*, vol. 27, p. 25.

Although the Taylor system has been applied to many types of industry other than machine shop production in which it originated, little has been published on these applications by those closest to the movement. Among the detailed discussions of other industries, however, must be mentioned the book by Mr. Charles Day,[1] dealing with the construction and layout of factories. Mr. Day points out the influence of the design of the plant upon the efficiency of operation and details the work incident to the planning and building of the plant, from the selection of the site to the construction of buildings and the installation of equipment. Excellent illustrations are given of the best layout and routing of materials in factories of different types. Mr. Gantt has published a short paper dealing with the textile industry,[2] and Mr. Day has pointed out the possibility of application to diverse industries including public service corporations.[3]

Growing out of the contributions of Mr. Taylor and his original group are a number of articles dealing with the theory of scientific management as it appears to those who first met it in its developed form. Among the most interesting of these are the Report of the Sub-Committee on Administration of the American Society of Mechanical Engineers.[4] This report, after pointing out the reasons for the present great popular interest in the subject, attempts to find the one basic principle in the movement, and discovers it in " the transference of skill." Just as the introduction of machinery meant " the transference of skill from the inventor or designer to the power-driven mechanism," so scientific management is the transference of skill from the manual worker to the planning department and functional foremen, resulting in the saving of labor and the increased output and reduction of cost. The report includes a collection of interesting

[1] *Industrial Plants*. Engineering Magazine Co., New York, 1911.

[2] " The Mechanical Engineer and the Textile Industry," *Trans. A. S. M. E.*, vol. 32, p. 499.

[3] " Management Principles and the Consulting Engineer," *The Engineering Magazine*, vol. 41, p. 133, reproduced in this volume, page 205.

[4] " The Present State of the Art of Industrial Management," *Journal A.S.M.E.*, vol. 34, pp. 1131–1150. Reproduced in this volume, page 153.

attempts to state the underlying principles of scientific management.

Mr. Forrest E. Cardullo[1] has compared "conventional," "systematic," and "scientific" management, with illustrations of administration of the various types. Then follows a discussion of the causes of current inefficiency, which may be grouped into three classes: those which are chargeable primarily to the employer, those which are chargeable primarily to the workman, and those which are chargeable primarily to our political and industrial system. They include mental laziness, prejudice against so-called "non-productive" labor, timidity of capital, lack of foresight and adaptability, mental inertia, lack of study of industry, inefficient wage systems, and avarice, on the part of the management; and on the part of the workmen, disinclination to work at other than their accustomed pace, lack of ambition, mental laziness, and enmity to their employers; and on the part of the political and industrial system, periodical depressions, seasonal variations in work, intense individualism, wasteful competition, and sudden changes in laws, customs, fashions, and social conditions. The paper closes with an enumeration of the objections to scientific management and the answers to them and is, on the whole, one of the best contributions to the subject.

Lieut. G. J. Meyers[2] has made an interesting attempt to deduce and formulate "laws" of management. He gives the following synopsis of laws: —

Law I. — What to do.
Law II. — Instructions before work starts.
Law III. — Machines and tools.
Law IV. — Workmen.
Law V. — Insure instructions are carried out.
Law VI. — Costs.
Law VII. — Study for improvements.

Each statement begins: "It is necessary in any activity." Thus Law I is in this form: "It is necessary in any activity to

[1] "Industrial Administration and Scientific Management," *Machinery*, vol. 18, pp. 843, 931; vol. 19, p. 18, reproduced in this volume, page 49.

[2] "The Science of Management," *Journal of the American Society of Naval Engineers*, vol. 23, p. 994.

have a complete knowledge of what is to be done and to prepare instructions as to what is to be done before the work is started," and so for each topic in the synopsis. The formulation of each law is followed by a brief statement of the reasons for it and the method of its application. The paper is a highly interesting essay in the formulation of industrial principles.[1]

The present writer[2] has pointed out that the time study methods of the Taylor system provide a definite basis for one side of the wage bargain: to wit, the content of a day's work, but makes no attempt to determine the equivalent day's wage, except to provide a means through the bonus or differential rate for the application of the principle that superior service should be paid at a superior rate.

M. LeChatelier's Introduction to the French translation of *The Principles of Scientific Management*,[3] discusses the fear both on the part of the employers and the workmen, that the radically new methods of scientific management will bring about critical economic problems of readjustment; and lays this fear to ignorance of the gradual working out of economic changes.

Mr. Morris L. Cooke, now director of Public Works in the City of Philadelphia, and one of the later additions to the original Taylor group, was retained by the Carnegie Foundation to make an investigation of academic efficiency from the point of view of

[1] To these should be added the following: Mr. H. P. Kendall's "Management: Unsystematized, Systematized and Scientific," *Scientific Management*, Tuck School Conference, 1912, p. 112; reprinted in *Industrial Engineering*, vol. 10, p. 374, a comparison of the types of management mentioned, reproduced in this volume, page 103, based on the writer's personal experience with the last two and a wide acquaintance with the first. Mr. Tracy Lyon's brief review of principles in "Scientific Industrial Operation," in *Technology and Industrial Efficiency*, p. 200, New York, 1911. Reprinted in *Iron Age*, vol. 87, p. 922, and in *Industrial World*, vol. 45, p. 464. Mr. A. Hamilton Church's "The Meaning of Scientific Management," *Engineering Magazine*, vol. 41, p. 97, which is one of numerous suggestive but unsuccessful attempts to find "the one" principle underlying the movement. Finally, the editorial "Scientific Management More Than a Labor Problem," *Industrial Engineering*, vol. 11, p. 467, pointing out the inclusiveness of the method.

[2] C. B. Thompson, "Relation of Scientific Management to the Wage Problem," *Journal of Political Economy*, vol. 21, p. 630, reproduced in this volume, page 706.

[3] Reproduced in this volume, page 842.

an industrial administrator.[1] In his report Mr. Cooke discusses current types of university organization, the college teacher as a producer, research, the economical use of buildings, functional activities, financial administration, and student administration. According to him, there is no present gauge to efficiency in academic work and, while recognizing that the product of the university is of so intangible a nature as not to be subject to exact measurement, he points out the possibility of the application of a unit, the student-hour, to the measurement of administrative efficiency. His discussion is brought to bear in detail upon the administration of a physics department and includes an application of some of the methods of industrial administration.[2]

Interesting suggestions for the partial or complete application of the Taylor system to varied industries are made by Mr. F. B. Gilbreth[3] when he shows the revolutionary result of the application of motion study to a trade so ancient as laying bricks, and by Mr. B. M. Ferguson[4] who details the favorable results of his experiments, particularly in its application to outdoor construction.

The success of the application of the Taylor system to the government arsenals drew the attention of engineers in the Navy to the possibility of its application to their branch of the service. This is discussed by Mr. C. S. Brewer[5] and by Lieut.-Commander W. B. Tardy.[6] Particularly interesting is the Report of the

[1] "Academic and Industrial Efficiency," *Carnegie Foundation Bulletin No. 5*, 1910.

[2] The following articles may be taken as samples of the comment provoked by this study: "Educational and Industrial Efficiency," *Science*, N.S., vol. 33, p. 101 by Richard C. Maclaurin, President of the Massachusetts Institute of Technology, who is apprehensive that the methods proposed by Mr. Cooke will consume too much of the time of officers of instruction and will tend to distract attention from the fundamental purpose of a university; "Educational or Administrative Efficiency," *Engineering Magazine*, vol. 40, p. 606 (anonymous); and "Scientific Management and Academic Efficiency," *The Nation*, vol. 93, p. 416 by Professor A. G. Webster.

[3] *Bricklaying System*. Clark Publishing Co., New York and Chicago, 1909.

[4] "The Application of the Taylor System to Gas Works," *American Gas Light Journal*, vol. 95, p. 225, and *Progressive Age*, vol. 29, p. 830.

[5] "Scientific Management in the Army and Navy," *World's Work*, vol. 23, p. 311.

[6] "A Plea for a Standard Organization of the Engineer Division Aboard Ship," etc., *Journal of the American Society of Naval Engineers*, vol. 23, p. 681.

Civilian Expert Board[1] on Industrial Management of United States Navy Yards. This Board, appointed by the Secretary of the Navy and consisting of Messrs. H. L. Gantt, Harrington Emerson, and Charles Day, investigated the present functions and conditions of navy yards. They discussed the efficiency of their management in comparison with that of industrial plants and made certain recommendations in regard to the nature of the work properly to be performed in navy yards and "that scientific management be introduced and perpetuated in the navy yards which it is decided to operate."

The most ambitious attempt to apply the Taylor principles to selling has been made by Mr. Charles W. Hoyt.[2] He describes such modern methods as training classes, salesmen's conventions, standardized talks, and outlines rather inadequately the application of the scientific method of approach to the problems of salesmanship.[3]

The growing realization that perhaps the greatest economic waste from which we suffer is due to the inefficient management of household economy has resulted in some thought being given to the working of the Taylor principles in domestic management. The most suggestive article on this subject is that by Mr. J. B. Guernsey,[4] which, however, is rather too vague and theoretical to be of practical service.

It is not strange that the best known and most popular books on the principles of scientific management are not those written by its originator and his co-workers; they are the product of persons who have been influenced by them and whose gift of expression is more highly developed. Foremost among these are two books by Mr. Harrington Emerson,[5] marked by a

[1] Prepared by direction of Hon. George von L. Meyer, Secretary of the Navy. Government Printing Office, Washington, 1912.

[2] *Scientific Sales Management.* Woolson & Co., New Haven, 1913.

[3] Other articles dealing briefly with this subject are Mr. Amasa Walker's "Scientific Management applied to Commercial Enterprises," *Journal of Political Economy*, vol. 21, p. 388, and Mr. J. George Frederick's "Applying the Science of Management to Selling," *Industrial Engineering*, vol. 12, p. 204.

[4] "Scientific Management in the Home," *Outlook*, vol. 100, p. 821.

[5] *Efficiency*, Engineering Magazine Co., New York, 1909, revised edition, 1912, and *The Twelve Principles of Efficiency*, 1911, revised edition, 1912.

breadth of interesting information, and a capacity for inspiring, almost poetic, elucidation, which have made them the most popular expositions of the subject.[1]

Mr. Emerson discusses certain typical inefficiencies and their significance, the causes of national industrial prosperity, the strength and weakness of existing systems of organization. He then proceeds to an exposition of his own method of line and staff organization, the determination and realization of standards, cost accounting, the location and elimination of wastes, and the Emerson bonus system. His method differs from that of Mr. Taylor in two respects: in the first place, in the line and staff organization, the staff consisting of the experts occupies an auxiliary and advisory relation to the management, whereas in the Taylor system, the experts are the functional foremen and are an integral executive part of the organization; in the second place, the Emerson bonus proceeds on the rough determination of a standard efficiency which he calls 100%; the workman who attains 67% or less gets his guaranteed day wages, and is paid a bonus on a sliding scale for every increase in the percentage of efficiency; at 100% the bonus amounts to 20% of his wages and 1% is added for each additional 1% of efficiency. As the task is not originally so accurately and thoroughly set as in the Taylor system, the workman can, and frequently does, exceed the 100% mark.

Mr. Emerson states the principles of management as follows: (1) clearly defined ideals; (2) common sense; (3) competent counsel; (4) discipline; (5) the fair deal; (6) reliable, immediate, and adequate records; (7) despatching; (8) standards and schedules; (9) standardized conditions; (10) standardized operations; (11) written standard-practice instructions; (12) efficiency reward. Most of these are not by any means peculiar to scientific management, nor can it be said that Mr. Emerson's application of them is distinctively original. Incidentally it is

[1] Two other simplified expositions worth mentioning are the *Primer of Scientific Management*, Van Nostrand Co., New York, 1912, by Mr. F. B. Gilbreth, and the misnamed "Psychology of Management," *Industrial Engineering*, vol. 11, pp. 343, 429; vol. 12, pp. 13, 65, 116, 155, 199, 248; vol. 13, pp. 18, 66, 113, 161, 213, by Mrs. L. M. Gilbreth.

interesting to note the gradual change from Mr. Emerson's acknowledgment of indebtedness to Mr. Taylor in certain discussions in the American Society of Mechanical Engineers to the reversal of this position in his later published work.

Out of the large number of books written within the last five years on the general subject of factory administration, four of the most important devote attention to a discussion of scientific management and show in general considerable influence by it. The most noteworthy of these are by Mr. Charles B. Going [1] and Mr. Dexter Kimball,[2] — these two are especially valuable for the setting they give scientific management in the development of modern administrative methods; Messrs. Galloway, Hotchkiss and Mavor; [3] and Mr. Hugo Diemer.[4]

It is natural that such a radical and far-reaching movement as scientific management should meet criticism. It has in fact been a veritable storm-centre. Much of the criticism is aimed at details and will be discussed later; but the following articles go for the system root and branch and should properly be enumerated here. The most comprehensive criticism is that by Admiral John R. Edwards,[5] who sums up the comments of most of the adverse writers, and adds on his own account that scientific management does not cover the whole of management, and that in any case management is an art rather than a science, that the Taylor system antagonizes the workmen and neglects the personal equation, and that whatever advantages have come from it have been incidental by-products. Another severe criticism is that by Mr. A. Hamilton Church,[6] who attacks particularly certain extracts from Mr. Taylor's writings, leading to the conclusion that Mr. Taylor does not show a science.[7] Mr. Church

[1] *Principles of Industrial Engineering.* McGraw-Hill Co., New York, 1911.

[2] *Principles of Industrial Organization.* McGraw-Hill Co., New York, 1913.

[3] *Business Organization.* Alexander Hamilton Institute, New York, 1912.

[4] *Factory Organization and Administration* McGraw-Hill Co., New York, 1910.

[5] "The Fetishism of Scientific Management," *Journal of American Society of Naval Engineers*, vol. 24, p. 355.

[6] "Has Scientific Management Science?" *American Machinist*, vol. 35, p. 108.

[7] The same point is made in an editorial called "The Science of Management Defined, and the Scope of this Science," *Engineering and Contracting*, vol. 39, p. 339.

and Mr. L. P. Alford [1] undertook to enumerate the principles of management and pointed out the place of the Taylor system in them.[2]

As already stated, most of the popular articles on the subject are obviously journalistic and ephemeral. The most spectacular discoveries of Mr. Taylor and his co-workers lend themselves easily to "popular" treatment; and the possible results of the application of the stop watch and the micrometer appeal effectively to the imagination of magazine and newspaper writers. Most of their work contains nothing new or significant. The few popular articles of real value are listed below.[3]

[1] "The Principles of Management," *American Machinist*, vol. 36, p. 857. Reviewed by Mr. D. S. Kimball and Mr. J. Calder, *ibid.*, p. 965.

[2] Other important general criticisms are those by Mr. Dexter S. Kimball, "Another Side of Efficiency Engineering," *American Machinist*, vol. 35, p. 263, reproduced in this volume, page 734, developing briefly some of the social and economic implications of the movement and calling attention to the absence of a discussion of distribution; by Mr. H. G. Bradlee, "A Consideration of Certain Limitations of Scientific Efficiency," in *Technology and Industrial Efficiency*, p. 190, New York, 1911; reprinted in Stone & Webster's *Public Service Journal*, vol. 8, p. 323, pointing out that for the most effective application conditions must be uniform, work repetitive and the area of operations small; by Mr. E. C. Peck, "Systematic versus Scientific Management," *Iron Age*, vol. 88, p. 364, drawing attention to the scarcity of real experts and the dangers of inexpert work; and by Mr. James R. Johnson, "A Manager's View of the Taylor System," *American Machinist*, vol. 34, p. 885, presenting the point of view of the typical successful manager, that we should let well enough alone.

[3] The following contain good enough ideas, well enough expressed, to warrant listing and recommending them: Mr. A. G. Popke's "The Relations of Capital, Labor and Efficiency in Manufacturing," *Engineering Magazine*, vol. 43, p. 857, pointing out the necessity of increasing efficiency; Mr. E. Perry's "The Outsider and the Busy Business Man," *ibid.*, vol. 40, p. 249, answering the old saw that improvement should come from the inside and not from the outside expert; a series of articles by Mr. E. M. Wooley. — "The One Best Way," *System*, vol. 20, pp. 227, 356, 460, 614; "Scientific Management in the Office," *ibid.*, vol. 21, p. 3; "Getting Out the Mail," *ibid.*, vol. 21, p. 284; "The Wanton Waste of Labor," *ibid.*, vol. 21, pp. 13, 173, "Lost Motions in Retail Selling," *ibid.*, vol. 21, pp. 366, 465, — well written and suggestive; Mr. H. S. Philbrick's "Scientific Management," *World To-day*, vol. 21, p. 1167, developing the idea that scientific management is a resumption of the direct oversight over production which had gradually vanished; an anonymous article, "What is Scientific Management, and What Does it Do?" *Industrial Engineering*, vol. 9, p. 1; an article, also anonymous, on "Efficiency Program," *Independent*, vol. 70, p. 739; an anonymous article entitled "Aspects of Scientific Management," *The Nation*, vol. 92, p. 464; and an excellent article by

2. Scientific Management in Operation

As yet nothing has been published summarizing the results of the application of scientific management in any large proportion of the plants which are using it. The nearest approach to a review of its present status is in the Report of the Sub-Committee on Administration of the American Society of Mechanical Engineers, referred to above. It is significant that one of the signers and, I believe, the actual writer of this report is Mr. L. P. Alford, mentioned above as one of the critics of the movement. Mr. Alford has written another excellent article,[1] based on the experience of a well-known Philadelphia company. Mr. A. W. Shaw, editor of the magazine *System*, gives a good brief review,[2] describing the work of the system at the Tabor Manufacturing Company in Philadelphia, and suggesting the method of its application to business problems in general and the results that might reasonably be expected from it. The experience of the Link Belt Company of Philadelphia is described by Mr. James M. Dodge, its president,[3] and a complete and detailed explanation of the operation of the Taylor system in that plant is given by Lieut. Frank W. Sterling.[4] The experience of the same plant is the basis of an article by Mr. C. W. Adams, its superintendent.[5] The same methods, as worked out by the Midvale Steel Company, are described by Mr. H. L. Arnold.[6] An excellent description of the early application of the system at the Bethlehem Steel

Mr. F. B. Copley, "How it Works: What Manufacturers and Workmen are Getting out of Scientific Management," *American Magazine*, vol. 75, p. 11, summarizing the results of an extensive investigation and approved personally by Mr. Taylor.

[1] "Scientific Management in Use," *American Machinist*, vol. 36, p. 548.

[2] "Scientific Management in Business," *Review of Reviews*, vol. 43, p. 327, reproduced in this volume, page 217.

[3] "A History of the Introduction of a System of Shop Management," *Trans. A. S. M. E.*, vol. 27, p. 720, reproduced in this volume, page 226.

[4] "The Successful Operation of a System of Scientific Management," *Journal of American Society of Naval Engineers*, vol. 24, p. 167, reproduced in this volume, page 296.

[5] "The Differential Piece Rate," *American Machinist*, vol. 34, p. 18.

[6] "Pre-eminent Success of the Differential Piece Rate System," *Engineering Magazine*, vol. 12, p. 831.

Works is published by Mr. H. L. Gantt,[1] and the story of its introduction and results at the Tabor Manufacturing Company is told by Mr. Wilfred Lewis, the president of the company.[2] The methods described in Mr. H. P. Kendall's paper [3] are in the main those of the large printing and binding establishment of which he is the general manager. Mr. Carl G. Barth gives an interesting anecdotal account.[4] Lieut.-Commanders W. B. Tardy [5] and A. M. Cook [6] give the results of the application of the principles of the system to gunnery practice and to the administration of a navy yard. The same subject is also dealt with by Mr. Holden A. Evans in a series of articles.[7]

Two extended and complete accounts are those by Mr. Charles B. Going and by General William Crozier. Mr. Going's article [8] describes the results achieved by Mr. Emerson in the application of his form of scientific management to the Santa Fe Railroad, and presents the conclusions of a disinterested spectator removed from the stress of the conflict between the railroad managers and their critics. It will be discussed in more detail in the next sec-

[1] "A Practical Application of Scientific Management," *Engineering Magazine*, vol. 41, p. 1.

[2] "An Object Lesson in Efficiency," in *Technology and Industrial Efficiency*, p. 173. McGraw-Hill Co., New York, 1911. Reproduced in this volume, page 232.

[3] "Management: Unsystematized, Systematized, and Scientific," *Scientific Management*, Tuck School Conference, 1912, p. 112. Abstract in *Industrial Engineering*, vol. 10, p. 374, reproduced in this volume, page 103.

[4] "Betterment of Machine-Tool Operation by Scientific Metal Cutting," *Engineering Magazine*, vol. 42, p. 586.

[5] Scientific Management and Efficiency in the United States Navy," *Engineering Magazine*, vol. 41, p. 545. *American Review of Reviews*, vol. 44, p. 229.

[6] "Scientific Management Methods at a Naval Magazine," *Engineering Magazine*, vol. 42, p. 75.

[7] "Reduction in Cost of Navy Yard Work," *American Machinist*, vol. 33, p. 1200; "General Instruction for Machine-Shop Methods," *ibid.*, vol. 31, p. 610; "Detailed Instruction for Machine-Shop Methods," *ibid.*, p. 645; "Do Taylor's Methods Increase Production?" *ibid.*, vol. 34, p. 1133; "Output under Scientific Management," *ibid.*, p. 1202.

The application to an automobile repair shop of the modification of the Taylor System used by Mr. Emerson and his disciples is described by Mr. A. Flack in "Machine-Shop Experience with the Principle of Efficiency Reward," *Engineering Magazine*, vol. 41, p. 641.

[8] "The Methods of the Santa Fe," *Engineering Magazine*, vol. 36, p. 909; vol. 37, pp. 9, 225, 337, 541.

tion. The reports by General Crozier on the application of the Taylor system to government arsenals [1] are exceptional in that they give detailed costs and comparisons to an extent not considered practicable by the managers of private concerns. The 1911 report gives an excellent brief résumé of the introduction of the system in the Watertown Arsenal, and a rather full demonstration of the statement that "the practical effect of these methods at the Watertown Arsenal has been a material reduction in the cost of general manufacture at that place," and describes the beginning of the trouble at that Arsenal with the molders and machinists. The 1912 report pursues the same subject and quotes comparisons of the cost of production at Watertown and other Arsenals where the system had begun to be installed with bids on the same items from outside concerns. The appendix to the 1913 report gives the recent petition of the Watertown employees for the abolition of the Taylor system, and the extended and conclusive reply of General Crozier.[2]

3. Scientific Management and the Railroads

In the Eastern Rate Case, the application of the railroads to the Interstate Commerce Commission for permission to raise freight rates was met by the shippers, under the advice of Mr. Louis D. Brandeis, with the counter-argument that, instead of raising the rates to spend more money, they should make their operation efficient to get more out of their present expenditure. In the course of the hearings, the following testimony was introduced:

Mr. Brandeis. You have been quoted, Mr. Emerson, as stating that in your opinion, by the introduction of proper efficiency system of scientific management, the railroads of the United States could effect an economy of perhaps $300,000,000 a year, or not less than $1,000,000 a day.

Mr. Emerson. That is correct — that is, I have been quoted as having stated that.

Mr. Brandeis. Is it your opinion that that is the fact?

Mr. Emerson. At least that.[3]

[1] Reports of the Chief of Ordnance for 1911, 1912, and 1913. Government Printing Office, Washington.

[2] Reproduced in this volume, page 741.

[3] Brief on Behalf of Traffic Committee of Commercial Organizations of the

Although, as stated above, the decision of the Commission was not affected by this testimony, the publicity it received stirred up an intense discussion, much of which on the part of the railroads showed signs of the spirit of the man who has been stung.

The best summary of the testimony bearing on this subject is by Mr. Louis D. Brandeis,[1] who has analyzed the meaning, the requirements, and the effects of scientific management, and who groups the evidence of the witnesses in accordance with the analysis. In an earlier article[2] Mr. Harrington Emerson had pointed out that, in his opinion, the railroads could save $300,000,000 a year, and his articles[3] suggest the method by which he approaches this conclusion. Mr. Emerson had been retained by the Santa Fe to develop his form of scientific management in part of their work and the results are described by Mr. Charles B. Going,[4] who outlines the problems of the road and describes Mr. Emerson's treatment of the stores keeping, shop order and works order systems, maintenance of motive power, the bonus system, the apprentice system, and relations with the employees. The bonus system is further described by Mr. Fred H. Colvin, editor of *The American Machinist.*[5]

Atlantic Seaboard, before the Interstate Commerce Commission, *re* Investigation of Proposed Advances in Freight Rates by Carriers in Official Classification Territory, p. 92.

[1] *Scientific Management and Railroads.* Engineering Magazine Co., New York, 1911. Ably reviewed by Mr. Edward D. Jones in the *American Economic Review*, vol. 1, p. 833.

[2] "Preventable Wastes and Losses on Railroads," *Railway Age Gazette*, vol. 45, p. 12.

[3] "How Railroad Efficiency Can be Measured," *Engineering Magazine*, vol. 42, p. 10; and "The Methods of Exact Measurement Applied to Individual and Shop Efficiency at the Topeka Shops of the Santa Fe," *American Engineer and Railroad Journal*, vol. 81, p. 221. Mr. Emerson's work in the Santa Fe work-shops is praised by Mr. W. J. Cunningham in the discussion of Mr. Taylor's address on scientific management before the New England Railroad Club (Oct. 10, 1911).

[4] "Methods of the Santa Fe," *Engineering Magazine*, vol. 36, p. 909; vol. 37, pp. 9, 225, 337, 541.

[5] "How Bonus Works on the Santa Fe," *American Machinist*, vol. 36, pp. 7, 165. See also two articles by Mr. Charles H. Fry, associate editor of the *Railway Age Gazette*, in the *Railway Age Gazette*, vol. 41, pp. 476, 504, followed by an editorial on the same subject, vol. 45, p. 413. Mr. Fry outlines the organization of the work on

Severe criticism of Mr. Emerson and his methods was made by Mr. Wilson E. Symons.[1] Mr. Symons attacks Mr. Emerson's statistics, shows the impossibility, in his opinion, of a million dollar a day saving, denies that Mr. Emerson's work on the Santa Fe was of any value, and gives examples of what he considers real railroad efficiency. Whatever may be the worth of Mr. Symons' statistics, it is evident to any one acquainted with scientific management that he knows practically nothing of the latter subject, and the paper is valuable mainly by reason of the discussion participated in by many well-known railroad men.[2]

The bitterness of the reaction by some railroad men is illustrated in a series of anonymous articles,[3] with such titles as "Extravagant Claims," "Impractical Theories," "Neglect of Human Element," "Unscientific Method and Impatience for Results," and "Neglect of Large Factors," which criticize severely some of the practices the writer had apparently met with. It is unfortunate that no means of identification are given, and there is apparently some point to the comment in the letter by Mr. F. L. Hutchins[4] to the effect that the writer of the articles

that road and illustrates with charts and statistics the results attained, particularly in machine shops.

It is generally understood that the influence of Mr. Emerson pervades the book of Mr. H. W. Jacobs, *Betterment Briefs*, Wiley & Sons, New York, 1909. 2d ed., dealing with Santa Fe machine shop improvements, reviewed in the *Railway Age Gazette*, vol. 47, p. 1192.

[1] "The Practical Application of Scientific Management to Railway Operation," *Journal of the Franklin Institute*, vol. 173, pp. 1, 140, 271, 365. See also his reply to an editorial criticism of his own paper in the *Railway Age Gazette*, vol. 51, p. 1107.

[2] In the same Journal appeared a defence of Mr. Emerson by Mr. C. J. Morrison, "Letter on Scientific Management," *Railway Age Gazette*, vol. 50, p. 214, and a fair criticism with acknowledgement of variation of the Emerson and the Taylor methods in an anonymous article on "What is Scientific Management?" *ibid.*, vol. 50, p. 839. Two good editorials on the subject are contained in *The Railway Age Gazette:* one of which, vol. 50, p. 18, holds that "the basic principles underlying scientific management are correct," and the other, vol. 50, p. 210, that "the value and effectiveness of scientific time study cannot be questioned." Some justification of Mr. Emerson's criticism of the efficiency of the railroads may be found in an article by Mr. L. C. Fritch, a well recognized railroad expert, on "Opportunities for Economy on Railways," *ibid.*, vol. 51, p. 1059.

[3] "The Mistakes of the Efficiency Men," *Railway Age Gazette*, vol. 50, pp. 29, 230, 391, 849, 1059, reproduced in this volume, page 615.

[4] *Railway Age Gazette*, vol. 50, p. 268, reproduced in this volume, page 632.

was mistaken in his classification of "efficiency men." The articles are well worth reading, however, as they appear to describe accurately the kind of things done by the many ill-prepared and inexperienced practitioners of "efficiency."

The objection to scientific management on the railroads on the ground that interference of the labor unions makes it impossible is voiced by Mr. J. O. Fagan [1] who reiterates his point that the difficulty with the railroads is the employees.[2]

Other fundamental objections to the application of scientific management to railroads are discussed by Professor W. J. Cunningham.[3] After stating the principles of the Taylor system, he discusses the testimony of Mr. Emerson and points out the vagueness of the methods proposed by him. He criticizes severely Mr. Emerson's statistics and particularly the method by which he arrives at the one million dollar a day saving. Acknowledging the success of scientific management in commercial undertakings, he points out four essential differences between manufacturing establishments and railroads: (1) area and extent of activity; (2) nature of product and output; (3) relations with the public and the government; and (4) relations with labor unions — any one of which, in his opinion, makes an application of the system to railroads impracticable. He then shows that the railroads have in fact for some time been applying scientific management of their own kind, and that the remedy for their administrative difficulties lies in a further application of the same methods by better and more efficient men.

Another railroad man, Mr. C. deL. Hine, in a stimulating and suggestive book,[4] develops the thesis that specialization has

[1] "The Dream of Scientific Management on Railroads," *Journal of Accountancy*, vol. 12, p. 1.

[2] See also the discussion between him and Mr. E. H. Abbott in "Humpty Dumpty's Question, and its Answer," *Outlook*, vol. 97, p. 543. The subject is also dealt with in an anonymous article in the *Iron Age*, "Railroad Efficiency and the Labor Unions," Feb. 23, 1911; and the responsibility for the problem is traced in an anonymous article, "Genesis of Railway Brotherhoods," *Railway Age Gazette*, vol. 50, p. 782; the point is also mentioned by Mr. W. D. Hines in "Scientific Management for Railways," *Nation*, vol. 91, p. 576.

[3] "Scientific Management in the Operation of Railroads," *Quarterly Journal of Economics*, vol. 25, p. 539, reproduced in this volume, page 580.

[4] *Modern Organization*. Engineering Magazine Co., New York, 1912.

already been carried too far on the railroads and that what they need is decentralization rather than the increased centralization characteristic of scientific management.[1]

One of the principal arguments of the railroads was that, so far as scientific management was applicable to railroading, it was already being applied, as was pointed out in Mr. Cunningham's article already referred to. An attentive study of the examples given by the railroad writers, however, shows that in the main they have mistaken isolated applications of scientific methods for the systematized organization of administration, which is meant by " scientific management." [2]

In the meantime, practical heed is being given to the possibility of making some form of application of the new system to railroading. For obvious reasons little is being published on this point, and any reference to the fact that the methods are those of Mr. Taylor or Mr. Emerson is carefully avoided.[3]

The fact seems to be, as expressed [4] by Mr. C. C. Leech, that " the efficiency men simply got in wrong " and that when personalities came to be forgotten, the railroad managers were as alive as any one to the possibilities of improvement.[5] As

[1] Attention should also be called to two editorials in the *Railway Age Gazette*, vol. 50, p. 265 and p. 387.

[2] See Mr. C. B. Brewer's " Substitute for the Rate Increase," etc., *Scientific American*, vol. 104, p. 596; Mr. B. S. Hinckley's " The Scientific Thought Applied to Railroad Problems," in *Technology and Industrial Efficiency*, p. 181. McGraw-Hill Co., New York, 1911; Mr. S. M. Felton's " Scientific Management of American Railways," *ibid.*, p. 221; and an anonymous article, " The Comparative Merits of Functional and Geographical Systems of Organization," *Engineering News*, vol. 64, p. 692.

[3] This is shown in the articles by Mr. W. J. Harahan on " Scientific Management," *Railway Age Gazette*, vol. 50, p. 212; by Mr. M. H. C. Brombacher on " Application of Scientific Management to a Railway Shop," *ibid.*, vol. 51, p. 23; by Messrs. H. F. Stimpson, L. W. Allison, J. S. Sheafe, and C. J. Morrison, on " Application of Scientific Management to a Railway Shop," *ibid.*, vol. 51, p. 33; and by Mr. B. A. Franklin on " An Efficiency Experiment Station for the Railroads," *Engineering Magazine*, vol. 42, p. 1.

[4] " A Letter on Efficiency," *Railway Age Gazette*, vol. 51, p. 221.

[5] An anonymous article, " Scientific Management of Railway Shops," *Machinery*, vol. 10, p. 16, calls attention to the steps taken by railroads to investigate efficiency as a result of the agitation; and an editorial in *Engineering and Contracting*, " The Railways and Scientific Management," vol. 35, p. 379, points out that scientific

evidence of the truth of this,[1] may be cited the work in the Canadian Pacific Shops where scientific methods have been installed by Mr. Gantt and maintained and developed by Mr. Vaughan, a leading railroad expert.[2]

4. Methods

In current discussions of scientific management so much emphasis has been laid upon such things as time study, motion study, functional foremanship, instruction cards, and slide rules that there is serious danger of these mechanisms of the system being taken for the system itself. With the warning, however, that detailed methods, either separately or in mere aggregation, are not scientific management, it is worth while to report the best of the articles and books which have appeared describing these methods. Nor is it superfluous to warn readers of these articles that the methods dealt with are so technical in their nature that their successful practice requires not only an expert in the method used, but an expert in the proper adjustment of these methods to each other and particularly to the entire spirit of scientific management.

There is an excellent series of articles dealing with the method of approach to the system,[3] most of which are amplifications of the

management is now being applied to the railroads, reproduced in this volume, page 610.

[1] In spite of the conclusion by Mr. George J. Burns in "Notable Efficiencies in Railway Machine-Shop Operation," *Engineering Magazine*, vol. 42, pp. 161, 386, 616, that the setting of standards in a railroad shop is impossible.

[2] "Canadian Pacific Shop Management," *American Machinist*, vol. 35, p. 1164; and "Scheduling Locomotive Repair Work on the Canadian Pacific Railway," *Industrial Engineering*, vol. 8, p. 380.

[3] The best of these are Mr. James M. Dodge's "The Spirit in Which Scientific Management should be Approached," *Scientific Management*, Tuck School Conference, p. 142; abstract in *Industrial Engineering*, vol. 10, p. 350, reproduced in this volume, page 286; Mr. H. K. Hathaway's "Prerequisites to the Introduction of Scientific Management," *Engineering Magazine*, vol. 41, p. 141, reproduced in this volume, page 268; the editor of *Industrial Engineering* has an excellent editorial on "Installation of Scientific Management," *Industrial Engineering*, vol. 10, p. 301; and there is a good article in the *Iron Age* by Mr. E. M. Taylor, "Modern Methods and the Business Specialist," vol. 84, p. 184. There is a suggestive and humorous account of the way not to do it, called "Echoes from the Oil Country," by Mr.

warnings so liberally scattered through Mr. Taylor's own books. The point of all of them is that no management should undertake to develop the Taylor system in its plant, unless it is prepared for a very considerable expenditure of time, money, and effort and a slow process of mental revolution on the part of itself and its employees.

Of the growing shelf of books on the entire subject, the best is of course Mr. Taylor's *Shop Management* referred to above. This book deals mainly with machine shop practice, but the principles and methods are developed in such a way that their application to other types of industry is not difficult if made by those sufficiently trained. The book on *Concrete Costs* by Mr. Taylor and Mr. Sanford E. Thompson, referred to above, applies scientific management to concrete construction. The other books detailing methods of application are written by men who have studied more or less with Mr. Taylor, or have been strongly influenced by his methods. One of the best of these is by Mr. F. A. Parkhurst,[1] which includes a series of articles reprinted from *Industrial Engineering*. The book includes an outline of the organization of a plant under scientific management, and detailed statements of the functions of all the principal functional foremen, an analysis of routing, stores systems and time study, a discussion of standardization and many illustrations of forms and appliances. The methods described are based on the practice of the Ferracute Machine Company, and differ only slightly from the approved practice of the original Taylor group. Another excellent book by Mr. Holden A. Evans, formerly Commandant of the Mare Island Navy Yard,[2] deals particularly with machine shop, smith shop, and woodworking shop methods, and illustrates reductions in cost accomplished by these methods in Navy Yards under the author's supervision. In addition to its treatment of costs, it is concerned mainly with such developments

W. Osborne, *American Machinist*, vol. 34, p. 1036; and another by Mr. H. K. Hathaway, in the discussion of Mr. Taylor's "Art of Cutting Metals," *Trans. A. S. M. E.*, vol. 28, p. 287, reproduced in this volume, page 279.

[1] *Applied Methods of Scientific Management.* Wiley & Sons, New York, 1912.

[2] *Cost Keeping and Scientific Management.* Wiley & Sons, New York, 1912.

in the direction of scientific management as may be undertaken by a manager not specially trained in the Taylor methods.[1]

The application of scientific management to foundries and machine shops is given in some detail by Mr. C. E. Knoeppel[2] in a series of articles reprinted from the *Engineering Magazine*. This is an interesting and well-written description of the application of scientific management as interpreted by Mr. Emerson and his disciples.[3]

The best articles describing the functions of the planning department are those by Mr. H. K. Hathaway,[4] in which he outlines briefly the duties of the functional foremen and illustrates the practical working of the extension of specialization to mental and supervisional work.

Perhaps the most distinctive feature of scientific management in the popular conception of the term is its time study. Current methods of time study, however, are frequently confused with the Taylor method. In ordinary practice watches are often used to determine roughly the time an operation usually takes, and the result is sometimes made the basis of a piece rate. This type of time study is known to the Taylor group as an "over-all" study and is never used by them. The Taylor method consists in the analysis of operations into their elementary units and the

[1] There is a good statement of underlying principles in Mr. Evans' article "Scientific Factory Management," *American Machinist*, vol. 33, p. 1108. The "System" Company of Chicago has published a little book, "How Scientific Management is Applied," Chicago, 1911, consisting of a series of reprints of *System* articles.

[2] *Maximum Production in Machine-Shop and Foundry.* Engineering Magazine Co., New York, 1911.

[3] Attention may be called to articles by Mr. Holden A. Evans, "Detailed Instructions for Machine Shop Methods," *American Machinist*, vol. 31, p. 16, and "An Analysis of Machine Shop Methods," *ibid.*, p. 468, and by Mr. Frederick A. Waldron, "Modern Methods of Shop Management," *Iron Age*, vol. 85, p. 982, which are almost too brief to be very useful.

[4] "The Planning Department," *Industrial Engineering*, vol. 12, pp. 7, 53, and 97. reproduced in this volume, page 366. With these should be read an anonymous article, "The Foreman's Place in Scientific Management," *Industrial Engineering*, vol. 9, p. 197, reproduced in this volume, page 395; and the criticism of functional foremanship in John Calder's "The Production Department," *Transactions*, The Efficiency Society, vol. 1, p. 155.

determination of the best methods and time for the performance of each of these units and their summation into a total time for the entire job.

The best descriptions of elementary time study as practised by the Taylor group of engineers are those by Mr. H. K. Hathaway [1] and by Mr. H. W. Reed.[2] A comparison of these articles with the tables of operating times given in Babbage's *Economy of Manufactures* will effectively dispose of any claim that the Taylor methods were anticipated by Babbage.

The practice of time study involves motion study. The aim of motion study is to determine the most effective motion to accomplish a desired result; and one of the elements in the determination of its effectiveness is the time it takes to execute it. Time study and motion study, therefore, go hand in hand, but it is not impossible to make an effective and profitable motion study without the use of any timing device. There is an interesting foreshadowing of modern motion study in an experiment carried out in 1837. This was described by Théotiste Lefevre,[3] a foreman in the famous printing plant of the Didots, who was struck with the fact that the traditional layout of the printer's case was not the one best adapted to the setting of type, in that usually the compositor had to reach farthest for the most frequently used letters. Lefevre, therefore, re-designed the case with a view to the maximum economy of effort and, after a test of both layouts adopted the revised case for his plant. After some years of struggle with the traditions of the printing fraternity, the new case was abandoned; but the experiment is a good early illustration of the application of motion study.

The best descriptions of motion study as such are given by Mr. Frank B. Gilbreth.[4] Mr. Gilbreth endeavors to list the variables affecting the efficient performance of manual work, and to point

[1] "Elementary Time Study as a Part of the Taylor System of Scientific Management," *Industrial Engineering*, vol. 11, p. 85, reproduced in this volume, page 520.

[2] "A Time Study under the Taylor System," *American Machinist*, vol. 35, p. 689. A good article is that by Mr. N. E. Adamson, Jr., "The Taking of Time Study Observations," *Industrial Engineering*, vol. 10, p. 439.

[3] *Guide Pratique du Compositeur*. Firmin Didot, Paris, 1883 (nouvelle edition).

[4] *Motion Study*. Van Nostrand Co., New York, 1911. See also ch. xiv of his *Bricklaying System*. New York, & Chicago, 1909.

out the extent of their influence. They are classed as variables of the worker, including anatomy, brawn, contentment, creed, earning power, experience, fatigue, habits, health, mode of living, nutrition, size, skill, temperament, and training; variables of the surroundings, including appliances, clothes, color, entertainment, heating, lighting, quality of material, rewards and penalties, size of unit moved, special fatigue-eliminating devices, surroundings, tools, union rules, and weight of unit moved; variables of the motion, including acceleration, automaticity, combination with other motions, cost, direction, effectiveness, foot-pounds of work accomplished, inertia and momentum overcome, length, necessity, path, play for position, and speed. The application of motion study to operations so small that they cannot be noted by the human eye unaided is accomplished by means of moving pictures.[1]

The result of properly directed time and motion study is the standardization of methods and equipment to secure the largest output in the minimum time with no material increase of effort. Once standardization is effected, the method is reduced in detail to writing in the form of an instruction card [2] which is given the operator as a guide to the accomplishment of the predetermined standard of production.

The multiplicity of data from which instruction cards are compiled must be reduced to such form that they can easily be

[1] "Micro-Motion Study — a New Development in Efficiency," *Scientific American*, vol. 108, p. 84. An illustration of the kind of results achieved is given by Mr. H. L. Gantt, "'Hipped' on Motion Study," *Industrial Engineering*, vol. 8, p. 307, and by Mr. William D. Ennis, "An Experiment in Motion Study," *ibid.*, vol. 9, p. 462. Professor Walter D. Scott, "The Rate of Improvement in Efficiency," *System*, vol. 20, p. 155, presents a useful side-light on its application. The following articles show how it may be used in fields outside manufacturing: Mr. E. M. Wooley's "Lost Motions in Retail Selling," *ibid.*, vol. 21, pp. 366, 465, "Getting out the Mail," *ibid.*, p. 284, and Mr. J. G. Frederick and Mr. H. S. McCormack's "Motion Studv in Office Work," *ibid.*, p. 563.

[2] These instruction cards are illustrated in the article by Mr. Hathaway on time study referred to above, and in the following: Mr. H. W. Reed's "Following a Fixed Schedule Under the Taylor System," *American Machinist*, vol. 35, p. 1020; and "Two Turret Lathe Instruction Cards," *ibid.*, vol. 36, p. 915. See also Mr. Frank B. Gilbreth's "The Instruction Card as a Part of the Taylor Plan of Management," *Industrial Engineering*, vol. 11, p. 380.

made available. Particularly is this true in the case of the conditions affecting the most economical cutting of metal. The vast body of information on this subject as given in such a work as Mr. Taylor's "Art of Cutting Metals"[1] must, for practical purposes, be made handy for use by the instruction card man. This is the purpose of the slide rules devised and described by Mr. Carl G. Barth.[2] Mr. Barth shows how the same methods by which slide rules for the solution of ordinary mathematical problems have been constructed, may be applied to the construction of slide rules for the solution of the more complicated mathematical problems involved in the determination of the proper speed, feed, and depth of cut for machine tools.

In spite of the fact that standardization is so fundamental a feature of scientific management, nothing of any consequence has been written on the subject.[3] In an article by Mr. P. Ballard,[4] the movement is criticized as not scientific, because its standardization methods stand in the way of progress. This illustrates a common fallacy in the discussion of standardization as that term is used by the scientific managers. It must be understood that standardization in their sense does not mean standardization of product, which is the common acceptance of the term, but the determination of the best material, equipment, and process discoverable at any given time and adherence to it until a better is found. So far from standing in the way of progress, this conception of standardization rather stimulates and aids more rapid improvement.

[1] *Trans. A. S. M. E.*, vol. 28, p. 31.

[2] "Slide Rules as Part of the Taylor System," *Trans. A. S. M. E.*, vol. 25, p. 49, reproduced in this volume, page 405.

[3] The best available is in an article by Mr. Charles Day, "Advanced Practice of Economical Metal Cutting," *Engineering Magazine*, vol. 27, p. 549, and in a book by Mr. C. U. Carpenter, *Profit-Making Management*. Engineering Magazine Co., New York, 1908. There is a brief but suggestive article by Mr. E. M. Wooley on "Scientific Management in the Office," *System*, vol. 20, p. 3, dealing with the standardization of office equipment and supplies, and a characteristic note by Mr. Frank E. Gilbreth on "The First Case of Standardization," *Trans.*, The Efficiency Society, vol. 1, p. 257, taking the shape of a brick as his example.

[4] "Scientific Management and Science," *Cassier's Magazine*, vol. 41, p. 425.

In the Taylor system, the term " routing " has two significations. Sometimes it refers to the physical layout of plants and the relationship of departments, — in this sense it is most completely treated by Mr. Charles Day;[1] more usually, however, it is concerned with the analysis of the sequence of operations on the work and the determination of the place and time for each operation and group of operations. On this latter, the most intricate feature of the system, practically nothing has been published[2] outside of Mr. Taylor's *Shop Management.*

Another characteristic feature of the Taylor system is the extensive use of classification and mnemonic symbolization. A series of articles by the present writer points out the purposes and methods of classification and mnemonic symbolization and its application to the various functions of costs, administration, stores system, routing, and filing.[3]

Although the Taylor system has a distinctive type of cost accounting, its details have not been published. The first part of Mr. Holden A. Evans' book[4] deals with the subject, but not exactly in the manner in which it is practised by the Taylor group.[5]

[1] *Industrial Plants.* Engineering Magazine Co, New York, 1911.

[2] The only reference of consequence outside the books is the article by Mr. H. L. Gantt, " The Mechanical Engineer and the Textile Industry," *Trans. A. S. M. E.*, vol. 32, p. 499.

[3] C. B. Thompson, " Giving a Business a Memory," *System*, vol. 22, p. 588; " Memory Tags for Business Facts," *ibid.*, vol. 23, p. 21; " Taking Factory Costs Apart," *ibid.*, p. 131; " Listing Stock to Index Wastes," *ibid.*, p. 260; " Keeping Tab on Finished Parts," *ibid.*, p. 386; " Right Filing and Easy Finding," *ibid.*, p. 286, reproduced in this volume, page 461.

The only other article on the subject is a brief abstract of a paper by Mr. H. G. Benedict, " The Mnemonic Symbolizing of Stores under Scientific Management," *Industrial Engineering*, vol. 12, pp. 24, 69.

[4] *Cost Keeping and Scientific Management.* McGraw-Hill Co., New York, 1911.

[5] Mr. A. Hamilton Church's *The Proper Distribution of Expense Burden*, Engineering Magazine Co., New York, 1908, and *Production Factors*, Engineering Magazine Co., New York, 1910, describe a method arrived at by him quite independently, which has been used in part for some time by the Taylor group. There is a brief anonymous article on " Cost and Time Keeping Outfit of the Taylor System," *American Machinist*, vol. 29, p. 761, and another by Mr. Charles J. Simeon on " The Scientific Management of a Foundry," *Iron Trade Review*, vol. 50, p. 68, which deal with some of the mechanical details.

The Taylor method of administering a tool room is admirably described by Mr. R. T. Kent,[1] emphasizing the importance of standardization, classification, maintenance, and control. The administration of belting is discussed by Mr. F. W. Taylor.[2]

Attention has often been called to the fact that the second cardinal principle in Mr. Taylor's system, the scientific selection and training of employees, has received no systematic treatment at the hands of the Taylor group, at least so far as selection is concerned. Training is duly emphasized and illustrated by Mr. Gantt in his *Work, Wages and Profits* referred to above. There are two good popular articles on the subject by Mr. E. M. Wooley, "The One Best Way," and "The Wanton Waste of Labor," referred to above. The only thing I have found on the selection of employees by any one even remotely connected with scientific management is a pamphlet by Mr. Harrington Emerson,[3] and this is an argument for the application of a system of selection which can only be characterized as a refined and slightly modernized phrenology, described in a book by the originators, Dr. Katherine M. H. Blackford and Mr. Arthur Newcomb.[4]

It must be evident from this survey that the literature dealing with the actual method of applying scientific management is as yet quite meagre. This situation is due to a number of factors, one among which is the natural reluctance of specialists to divulge the details of their profession, because of their apparently well-grounded fear that the attempt to describe methods which must be modified to meet a wide variety of contingencies must necessarily be inadequate and to a certain extent misleading, and that therefore it is safer not to attempt at all to describe them in writing. In view, however, of the rapid extension of scientific management to many varieties of industries, and the comparative scarcity of qualified "experts," it appears that the time is ripe for such an exposition of methods as may be immediately

[1] "The Tool Room under Scientific Management," *Industrial Engineering*, vol. 9, p. 87, reproduced in this volume, page 434.

[2] "Notes on Belting," *Trans. A. S. M. E.*, vol. 15, p. 204.

[3] *The Scientific Selection of Employees*. The Emerson Company, 30 Church Street, New York.

[4] *The Job, the Man, the Boss*. Doubleday, Page & Co., New York, 1914.

and directly useful to any manager of the requisite intelligence to sense their place in the system and to apply them with the thoroughness and discretion necessary.

This criticism of meagreness does not apply to one of the principal methods of scientific management, — the use of wages as an incentive. There is nothing new about such use of wages, but the method of the Taylor group is characteristically different. With them wages are not used primarily as an incentive to production but as an incentive to the acceptance of standardized conditions and training and the following of instructions. Increased production is the direct result not of the bonus or differential piece rate systems but of the utilization by the employee, in consideration of higher wages, of the improved methods, materials and equipment provided him by the management. This was the point, though it is not made very clear, in Mr. Taylor's paper on "A Piece Rate System and Shop Management" referred to above, and it runs all through Mr. Gantt's *Work, Wages and Profits.*[1]

[1] This is brought out a little better by Mr. Harrington Emerson in a paper on "A Rational Basis for Wages," *Trans. A. S. M. E.*, vol. 25, p. 868. Out of the mass of books and articles on this subject, the following are also suggested, not necessarily because they are written by members of the Taylor group, which few of them are, but because a study of them will help make clear the philosophy of the use of wage systems by that group. The following are comparative discussions of various methods of wage payment: Mr. S. E. Thompson's "The Taylor Differential Piece Rate System," *Engineering Magazine*, vol. 20, p. 617; "Differential Piece Rates" (anonymous), *Engineering*, vol. 80, p. 413; Mr. Clive Hastings' "The Efficiency of the Worker and His Rate of Pay," *American Engineer & Railroad Journal*, vol. 81, p. 238; Mr. Harrington Emerson's "Different Plans of Paying Employees," *Iron Age*, vol. 82, p. 1150; and Mr. C. B. Thompson's "The Reason for a Payroll," *System*, vol. 22, p. 249, and "When Higher Wages Pay," *ibid.*, p. 339, reproduced in this volume, page 684. To get one's bearings in the discussion, the articles by Messrs. Towne, Halsey and Rowan, referred to above, should be read, and the following: Mr. W. O. Walker's "The Value of Incentives," *American Machinists*, vol. 26, p. 996; and Mr. C. J. Morrison's "Piece Rates versus Bonus," *ibid.*, vol. 36, p. 178. Highly interesting in this connection are also Mr. Carroll D. Wright's "Profit Sharing," Bureau of Statistics of Labor, No. 15; and the Report of the British Board of Trade on Profit Sharing and Labour Co-partnership in the United Kingdom. Wyman & Sons, London, 1912.

5. The Personal Factor in Scientific Management

The apparently cold-blooded statements of Mr. Taylor in *Shop Management* and *The Principles of Scientific Management* in regard to his methods of training employees and the mathematical determination of the incentives which actuate their conduct have led to a considerable discussion of the treatment of the " human factor " by scientific management. Discussion is usually based on the truisms that system cannot take the place of honesty and intelligence, that specialization can be carried too far, that driving is an undesirable feature of factory management, that the workmen should not be made into automata, that they should not be set working against each other's interests, that attention should not be centered exclusively upon men above the average of ability, that the factors of habit and prejudice should not be ignored, that no solution of economic problems is complete which ignores the problem of distribution, and that the desires and aspirations of the men toward self-government and democracy must be recognized. Most of these points are mentioned in the Report of the House Committee on Labor appointed to investigate the Taylor and other Systems of Management,[1] leading to the conclusion that no recommendations were necessary, presumably because the criticisms suggested did not apply to the Taylor system.

The importance of a consideration of the human problem is emphasized by Mr. William C. Redfield.[2] The nature of the psychological problems involved and an indication of the method of approach to their solution are discussed at some length by Professor Hugo Münsterberg.[3] The significance of the work begun by Mr. Taylor and his associates as it appears to a psychologist is emphasized, and examples are given of the more refined methods by which the psychological laboratory may be made an aid in the discovery of principles for industrial application.[4]

[1] Government Printing Office, Washington, 1912.

[2] " The Moral Value of Scientific Management," *Atlantic Monthly*, vol. 110, p. 411.

[3] *Psychology and Industrial Efficiency*. Houghton, Mifflin Co., Boston, 1913.

[4] The fear that scientific management is an effort to substitute a system for integrity and ability is voiced by Mr. F. J. Whiting in " The Personal Equation in

In a remarkable book by Miss Josephine Goldmark,[1] there is a suggestion that, although scientific management has thus far avoided the pitfall of driving, there has not been the intensive and scientific study of fatigue which might reasonably be expected from the scientific attitude of the leaders in the movement. Mr. F. H. Dwight[2] insists that the bonus as applied at the Bethlehem Steel Works is but another method of driving. The completest answer to the criticism of practice, no matter what may be said in regard to the absence of a scientific study of fatigue, is made by Clark and Wyatt,[3] who give the results of an intensive investigation of the effect of the Taylor system on women employed under it. This inquiry, begun with the expectation of finding the science of driving reduced to practice, ended after exhaustive personal study in many plants in a complete exoneration of the Taylor-Gantt methods from this charge.[4]

The criticism that scientific management suppresses the initiative and ambition of the workman is presented by Mr.

Scientific Management," Stone & Webster's *Journal*, vol. 8, p. 411. The fear of over-specialization finds expression in an editorial in *Engineering* (London) on "Scientific Management," vol. 93, p. 289, and is apparently the point of an article by Dr. Luther H. Gulick on "The Human Element," *Transactions* of the Efficiency Society, vol. 1, p. 181, and of one by Mr. A. Hamilton Church on "Intensive Production and the Foreman," *American Machinist*, vol. 34, p. 830. The answer to these may be deduced from Mr. M. P. Higgins' "Intensified Production and Its Influence upon the Worker," *Engineering Magazine*, vol. 20, p. 568; Mr. Frank H. Rose's "The Rise of Labor Through Labor-Saving Machinery," *ibid.*, vol. 27, p. 836; Mr. A. E. Outerbridge, Jr.'s "The Educational Influence of Machinery," *ibid.*, vol. 9, p. 225, and "The Emancipation of Labor by Machinery," *ibid.*, p. 1012. The value of scientific management in finding the place to which the laborer is best fitted and in fitting the man perfectly to fill it is emphasized in an editorial in *Machinery*, "Helping a Man to Find His Place," vol. 18, p. 279; in Mr. David Van Alstyne's "Profitable Ethics," in *Technology and Industrial Efficiency*, p. 207, McGraw-Hill Co., New York, 1911; and in Mr. Harrington Emerson's "Ethics and Wages," *Outlook*, vol. 99, p. 682.

[1] *Fatigue and Efficiency*, The Russell Sage Foundation. New York, 1912.

[2] "The Taylor System as a Machinist Sees It," *American Machinist*, vol. 34, p. 989.

[3] *Making Both Ends Meet*. The Macmillan Co., New York, 1911. See especially chap. 7, reproduced in this volume, page 807.

[4] Other significant articles on the same subject are: "Scientific Management as viewed from the Workmen's Standpoint," *Industrial Engineering*, vol. 8, p. 377, reproduced in this volume, page 835, and Mr. Wilfred Lewis' "F. W. Taylor and the Steel Mills," *American Machinist*, vol. 34, p. 655.

Frank C. Hudson [1] and further discussed by Mr. Holden A. Evans,[2] and particularly and most effectively by Mr. Charles B. Going [3] who points out that one distinctive feature of the modern systems of management is the restoration of the individuality of the workman.

The complaint that the effect of the task and bonus method is to concentrate the efforts of each workman exclusively upon his own success and well-being, has not been dignified with a formal article, but is given expression occasionally in the hearings before the House Committee on Labor. It is pretty effectively answered in an article by Lieut. E. D. K. Klyce,[4] which points out the absolute necessity of mutual helpfulness and coöperation in the Taylor system.

Mr. Taylor talks so much about the "first class man" and has emphasized so little his explanation that by the first class man he means the man adapted to the job he is doing, that the supposition is only natural that this system aims at the selection of the best only and the elimination of the average and mediocre.[5] Illustrations given by Mr. Taylor do unquestionably show the strongly selective effect of his method; but this should not be allowed to distract attention from the effect of systematic training on the development of average and mediocre into "first class" men.

The undue haste with which outside followers of scientific management have attempted to revolutionize the methods and habits of thought of workmen and employers has called forth impressive and valuable warnings from Mr. James Hartness.[6]

The relation of scientific management to larger social problems is hinted at by Mr. Taylor in *The Principles of Scientific Manage-*

[1] "The Machinist's Side of Taylorism," *American Machinist*, vol. 34, p. 773.

[2] "Effect of the Taylor System: What is to Become of the Mechanic?" *American Machinist*, vol. 33, p. 1095.

[3] "The Efficiency of Labor," *Review of Reviews*, vol. 46, p. 329.

[4] "Scientific Management and the Moral Law," *Outlook*, vol. 99, p. 659.

[5] This misunderstanding underlies the criticism in Mr. John R. Godfrey's "Eliminating the Inefficient Man," *American Machinist*, vol. 34, p. 1232.

[6] "The Factor of Habit," *Transactions*, The Efficiency Society, vol. 1, p. 237. Still more effective is his book, *The Human Factor in Works Management*. McGraw-Hill Co., New York, 1912.

ment and the ultimate bearing of the application of the system to social welfare, through the reduction of the cost of production and the increase of the purchasing power of the consumer, is briefly suggested. If it could be supposed that the tendencies inherent in the system would be allowed to work themselves out to their logical conclusions, social and economic consequences of a far-reaching nature would reasonably be expected. This possibility has raised unduly the hopes and enthusiasm of some of the advocates of the movement and has brought down upon it the criticism of those calmer individuals who realize, in the first place, that no economic tendency ever does or can work out to its logical conclusion, and, in the second place and particularly, that production and consumption are but a part of the entire economic problem. Those who are looking for a panacea for social ills and who suppose that scientific management was offered as such a panacea are keen to point out that it does not deal finally with the problem of distribution. Professor Edward D. Jones [1] was acute enough to see that Taylor's work developed a principle of distributive justice, namely, the rewarding of the individual for his individual performance, and was not disappointed that it did not go further in this matter than it professed to go. Mr. Dexter S. Kimball in the article mentioned above, Mr. Ralph E. Flanders,[2] and Mr. W. H. Herschel [3] have pointed out, with the air of making a discovery, that the Taylor system does not solve the problem of distribution. Mr. Louis Duchey [4] hails the failure of the system to solve the system of distribution and its one-sided emphasis on production as the force which will do most to intensify class consciousness and hasten the destruction of capitalism.

[1] Review of Taylor's "Shop Management," *American Economic Review*, vol. 2, p. 369.

[2] "Scientific Management from a Social and Economic Standpoint," *Machinery*, vol. 18, p. 764.

[3] "Social Philosophy and the Taylor System — Will the Ultimate Result of the Taylor System be Beneficial?" *Engineering News* (London), vol. 65, p. 577.

[4] "Scientific Business Management. What is it? What effect Will it Have on the Revolutionary Movement?" *International Socialist Review*, vol. 11, p. 628.

The test of democracy has, of course, been applied to this movement. Mr. Meyer Bloomfield[1] points out, apparently with some misgiving, that the loyalty of the employee must be secured by keeping the enterprise democratic; while Mr. Paul U. Kellogg,[2] one of the editors of the *Survey*, is more specific to the effect that this new industrial force must be socialized. Mr. Frank T. Carlton[3] goes still further by pointing out how the movement should be made democratic by giving the workman a voice in the determination of the conditions and the rate of bonus under which he will work. Scant agreement with this conception can be found in the writings of Mr. Taylor. His attitude and that of men of similar training and experience[4] is that the employee has no right to control or participate in the management of the establishment. If this is strictly true, there is obviously in scientific management no place for recognition of trade unionism, the collective bargain, and other mutually agreed arrangements.

6. Scientific Management and Organized Labor

The attitude of Mr. Taylor and his immediate followers toward labor organization is difficult to determine from their writings. Thus he says, in *Shop Management:* "There is no reason why labor unions should not be so constituted as to be a great help both to employers and men. Unfortunately, as they now exist they are in many, if not most, cases a hindrance to the prosperity of both." He acknowledges the current obligation of society to organized labor for increased safety, shorter hours and in some cases better working conditions. It appears to be his belief, however, that where scientific management is practised fully and completely, the working man is automatically protected by the self-interest of his employer, owing to the fact that the adminis-

[1] "Scientific Management: Coöperative or One-Sided," *Survey*, vol. 28, p. 312.

[2] "A National Hearing for Scientific Management," *Survey*, vol. 25, p. 409.

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Whatever Mr. Taylor's real view of the matter may be, the fact is that the labor unions have taken a violent antipathy to scientific management. This is at least partly due to what one writer calls Mr. Taylor's "unfortunate and tactless statements" [1] in regard to labor. There are, however, other and more fundamental reasons for this lack of agreement. An anonymous writer in the *Electrical Railway Journal* [2] points out that specialization, through its easy training of the unskilled, strikes at the heart of labor unionism as at present organized. An editorial in the *World's Work* [3] prophesies that "the foolish unions will oppose it as they opposed the introduction of machinery, and lose." *The Century Magazine* [4] observes that the labor union insists upon "equality." Mr. G. F. Stratton in the *Outlook* [5] finds the point of divergence in the fact that the unions set a minimum wage which the employers treat as a maximum. The chief reason, however, appears to be found in the policy of restriction of output. The belief that restriction of output is a confirmed labor union policy is apparently borne out by the Eleventh Special Report of the United States Commissioner of Labor, on the Regulation and Restriction of Output,[6] — one of those government reports which, like the report on the hearings before the Labor Committee investigating the Taylor System and the Report of the Civilian Expert Board on Industrial Management of the United States Navy Yard, which favored the applica-

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[5] "Ca-Canny and Speeding Up," vol. 99, p. 120.

[6] Government Printing Office, Washington, 1904.

The test of democracy has, of course, been applied to this movement. Mr. Meyer Bloomfield [1] points out, apparently with some misgiving, that the loyalty of the employee must be secured by keeping the enterprise democratic; while Mr. Paul U. Kellogg,[2] one of the editors of the *Survey*, is more specific to the effect that this new industrial force must be socialized. Mr. Frank T. Carlton [3] goes still further by pointing out how the movement should be made democratic by giving the workman a voice in the determination of the conditions and the rate of bonus under which he will work. Scant agreement with this conception can be found in the writings of Mr. Taylor. His attitude and that of men of similar training and experience [4] is that the employee has no right to control or participate in the management of the establishment. If this is strictly true, there is obviously in scientific management no place for recognition of trade unionism, the collective bargain, and other mutually agreed arrangements.

6. Scientific Management and Organized Labor

The attitude of Mr. Taylor and his immediate followers toward labor organization is difficult to determine from their writings. Thus he says, in *Shop Management:* "There is no reason why labor unions should not be so constituted as to be a great help both to employers and men. Unfortunately, as they now exist they are in many, if not most, cases a hindrance to the prosperity of both." He acknowledges the current obligation of society to organized labor for increased safety, shorter hours and in some cases better working conditions. It appears to be his belief, however, that where scientific management is practised fully and completely, the working man is automatically protected by the self-interest of his employer, owing to the fact that the adminis-

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tion of scientific management to the navy yards, was suddenly and mysteriously "out of print" almost immediately after publication.

As was seen in an earlier section, railroads in their controversy with the scientific managers have not hesitated to point to the opposition of the labor unions as one of the reasons for the impracticability of the application of the system to their industry, and to substantiate their argument, as in an article in the *Iron Age*[1] by quoting the restrictive laws of such an organization as the International Iron Molders' Union.[2]

The published expressions of labor union leaders referring directly to scientific management have ranged from an attitude of suspended judgment to one of bitter antipathy. Mr. John Golden of the Textile Workers,[3] is non-committal but suspicious. Mr. J. P. Fry of the Iron Molders[4] is sure that it is at least unscientific. Mr. James Duncan, vice-president of the American Federation of Labor,[5] conveys the impression that scientific management is the summation of all the evils of all the generations of oppression of the working man. Yet this opinion is mild compared with that of the before-mentioned Mr. James O'Connell (now a member of the National Commission on Industrial Relations, which just now is once more investigating scientific management) in an official letter to Machinists' Unions, in which he says: "Wherever this system has been tried it has resulted either in labor trouble and failure to install the system, or it has destroyed the labor organization and reduced the men to virtual slavery and low wages, and has engendered such an air of suspicion among the men that each man regards every other man as a possible traitor and spy. . . . We trust that you will be impressed with the importance of this matter, and will see the

[1] "Railroad Efficiency and the Labor Unions," vol. 87, p. 476.

[2] Other interesting articles on the attitude of the unions towards premium plans are those by Mr. H. M. Norris, "Actual Experience with the Premium Plan," *Engineering Magazine*, vol. 18, pp. 572, 689, and Mr. James O'Connell, "Piece Work not Necessary for Best Results in the Machine Shop," *ibid.*, vol. 19, p. 373.

[3] "The Attitude of Organized Labor," *Journal of Accountancy*, vol. 12, p. 189.

[4] "Relation of Scientific Management to Labor," *Iron Trade Review*, vol. 52, p. 917.

[5] "Efficiency," *Journal of Accountancy*, vol. 12, p. 26.

impending danger. Act quickly." The published articles in newspapers on this subject are very numerous; they are not listed here as they are variations on the same theme.

The Machinists Union and after it the American Federation of Labor have made the application of scientific management in government arsenals, particularly in the arsenal at Watertown, Massachusetts, the object of their official attack. Reference has already been made to the report of the committee appointed to investigate the trouble there in 1911. In the 1913 report,[1] General Crozier deals with the recent petition of the Watertown employees referred to above. This petition is evidently the first gun in the campaign inaugurated by the American Federation of Labor at their 1913 convention in Seattle, at which they decided officially to fight the extension of the Taylor system.[2]

The best articles counselling the unions to take a saner point of view are those by Mr. Louis D. Brandeis,[3] in which he argues that scientific management is but the application of thought and knowledge to industry, that increased efficiency and production operate in the interest of the working man, and that its progress and ultimate success are inevitable. The same thought is expressed by Mr. Harrington Emerson.[4]

On the other hand, scientific managers have been freely advised to recognize more fully the necessity of coöperation with the unions. This is the attitude of Mr. John R. Commons,[5] who points out that the bonus system implies an individual bargain with the workman, and therefore strikes at the very existence of the union, unless its terms can be made the subject of a collective

[1] Report of the Chief of Ordnance, 1913. Government Printing Office, Washington. Reproduced in this volume, page 747.

[2] Interesting articles bearing on the subject are those by Mr. Max H. C. Brombacher, "The Rock Island Arsenal Labor Trouble," *Iron Age*, vol. 89, p. 476; by Lieut.-Colonel W. S. Peirce on "Government Shop Management," *ibid.*, p. 476; and an article, "Scientific Management at United States Arsenals," *ibid.*, vol. 88, p. 1022, which includes a statement of former Secretary of War, Stimson.

[3] The New Conception of Industrial Efficiency," *Journal of Accountancy*, vol. 12, p. 35, and "Organized Labor and Efficiency," *Survey*, vol. 26, p. 148.

[4] "The Fundamental Truth of Scientific Management," *Journal of Accountancy*, vol. 12, p. 17.

[5] "Organized Labor's Attitude Towards Industrial Efficiency," *American Economic Review*, vol. 1, p. 463.

bargain; of Dr. John H. Gray,[1] and of the present writer,[2] who holds that the labor unions may and should assist in the determination of the standardized conditions and of a day's work and its attainment, and that the existence of the unions is and will continue to be necessary to maintain an adequate minimum wage.

[1] "How Efficiency should benefit the Employer, the Employee, and the Public," *Transactions*, The Efficiency Society, vol. 1, p. 67.

[2] C. B. Thompson, "The Relation of Scientific Management to the Wage Problem," *Journal of Political Economy*, vol. 21, p. 630, reproduced in this volume, page 706.

INDUSTRIAL ADMINISTRATION AND SCIENTIFIC MANAGEMENT

By FORREST E. CARDULLO

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I

What Constitutes Scientific Management

The work of the engineer may be divided into three great departments, since it has to do with the design of machinery, the methods of constructing and operating it, and the administration of the plants in which it is constructed and operated. The first two departments (namely the design of machinery, and its construction and operation) have received the careful attention of trained specialists for more than a century. Even at the beginning of the nineteenth century when engineers first began to apply the resources of modern science to their work, the arts of machine design and construction were in an advanced state, owing to the efforts of many generations of skilled mechanics. The third department of engineering work, however, has lagged far behind the other two, since comparatively little attention has been bestowed upon it. It is doubtful if any substantial advance in industrial administration was made in the thirty centuries preceding the year 1880, and even at the present time only a few men are devoting serious attention to the fundamental problems of management.

IMPORTANCE OF INDUSTRIAL ADMINISTRATION

At the present time, industrial administration is the most important of the three departments of engineering work. It is not, of course, confined to purely engineering projects, but is an essential part of all commerce and manufacturing. Since the greater part of our working population is engaged in some kind of industrial work, the proper supervision of their efforts is a matter of prime importance to the well-being of the country.

Most of the readers of *Machinery* are, or ought to be, interested in the proper administration of the mechanical industries. Hence this series of articles will discuss more particularly the management of shops and factories engaged in the metal trades.

As has already been intimated, the art of industrial administration was stationary for a long period of time. In spite of tremendous changes in our social, economic and industrial systems, we have been content to adapt or modify methods which originated thousands of years ago. I may liken the system of administration which obtains in most industrial plants to one of those "old homesteads" which dot our New England landscape. They started as a log cabin, to which was successively added a lean-to, a barn, a shed, an ell, an upper story, and other "modern conveniences." As a result, they are roomy — and also inconvenient. The common system of industrial administration is constructed of the surviving remains of Greek slavery, Roman militarism, Saxon serfdom, the mediaeval guilds, and various other historical oddities, slightly altered to adapt them to the twentieth century conditions, and engrafted on one another in very much the same way as the additions to the old house. This system of management has been a growth in which each manager appropriated those developments of the past which appealed to him. Sometimes methods were adopted as a result of a carefully and properly conducted investigation, but nine times out of ten they were adopted because the manager "guessed" they were the best ones.

CONVENTIONAL MANAGEMENT

We will designate the system of management described in the preceding paragraph as "conventional management." It must not be inferred from the description the writer has given that conventional management is always and utterly objectionable. When the manager is a good guesser, he will usually choose good methods of work. If his lieutenants are able and energetic, these methods will be well carried out. Of course the system is not perfect, and in many cases it is not even satisfactory. Nevertheless conventional management can be made to work, and to work well, when it is in the hands of capable administrators. Different men will, of course, adopt different methods, and in different shops we will find that the work of administration is carried out in very different ways. In every case, however, the distinguishing feature of conventional management is the acceptance of something already in existence and the choosing, by guess, between methods which have been developed by some one else.

SYSTEMATIC MANAGEMENT

Within the past thirty years, however, two other systems of management have arisen. One of these may be called "systematic management," while the other has been named by its originators, "scientific management." The systematic system of management is the development of the clerk and the bookkeeper. It aims at the keeping of careful records and the collecting and classification of information. It aims to proceed by continually bettering existing records. It aims to inform the management as to the preferable one of two alternative methods of work, each of which must be tried out in practice. Systematic management is, then, simply the keeping and comparison of records in order to determine the relative value of methods of work.

SCIENTIFIC MANAGEMENT

Scientific management, on the other hand, has been developed by the engineer. Scientific management aims at the careful investigation of every problem of the industrial world in order to determine its best solution. It is not content to rely upon records, or upon the judgment of the most experienced workman. It brings to its aid all the resources of science. Every possible method of performing a piece of work is carefully analyzed and the best elements of all of the methods combined in order to form a new method. Having established the best methods of work, scientific management then instructs the workman how best to perform his task, and offers an incentive to do it in the prescribed manner. Scientific management is often called the "Taylor System" in honor of its foremost exponent.

Scientific management is not an invention but a discovery. It is the application of the scientific method of research to the problems of the industrial world. In so far as it is concerned with the investigation of these problems, it is science and nothing else. In so far as it is concerned with the proper application of the results of these investigations, it is management and nothing else. The combination is therefore correctly termed " scientific management."

Just as in the old days, certain types of machinery reached a very high state of development without the aid of the scientifically trained engineer, so in these days, the administration of certain of our industries has been very highly developed without the aid of scientific management. In some kinds of work, as for instance, watch making, the problems of administration are simple on account of the limited character of the product and the extensive use of automatic machinery. In industries of this class reasonable piece rates have been established by a series of cuts and other prolonged labor troubles. Such industries have arrived at an efficient system of management by a very strenuous and unpleasant process, and the adoption of scientific management would not always bring notable advantages. On the other hand, most industries are not in this class. The character of the labor employed, the quantity and character of the output, the kind of machinery used, and the kind of material supplied is continually changing. In the first class of industries a process of evolution extending over two or three generations has established the best methods of management. In the second class of industries the best methods are continually changing as conditions change.

In most industries, the introduction of scientific management promises to effect great gains, and to greatly increase the efficiency of our whole industrial system. Scientific management has been applied to many different kinds of work, and seems to be almost if not quite universal in its application. It has brought to light many problems in connection with industrial administration of whose very existence we were previously ignorant. Every time it is applied to a new set of conditions, even in the same industry, new problems are presented. If, in the near future, it is extensively applied to all industries or even to any one industry, it will give rise to very serious political, social and economic problems as well as intensify a great many of the problems that are now pressing for a solution. It will be seen, then, that the application of scientific management in industrial administration is not only important to the factory owner, the superintendent, and the workman, but to the law maker, the citizen and, in fact, to every man, woman and child in the country. The field of industrial administration is a very great one, but we cannot appreciate the importance of a right understanding of the problems which will be raised by the extensive introduction of scientific management until we realize how this field is interrelated with our entire political and social system.

AN EXAMPLE OF EFFICIENT MANAGEMENT

It is a fact which cannot be controverted, that very few shops in this country produce more than sixty per cent of the work which it would be possible for them to produce with the same wage roll and the same physical equipment. A few of the best managed shops produce probably eighty per cent of the work which it would be possible for them to produce; and occasionally departments in well managed shops reach an efficiency of over ninety-five per cent. On the other hand, there are numerous shops in this country which, without any considerable change in their equipment or increase in their wage roll, could produce from three to five times as much work as they put out at present. This statement, extraordinary as it may seem, is not the result of a wild guess, but may easily be verified by any one who will make a study of conditions in these shops. Some two years ago, the writer made a trip through southern New England inspecting some of the representative industries. The most efficient department that I ever saw was the grinding department of the Norton Grinding Co., Worcester, Mass. I do not know that the engineer, Mr. Norton, made a conscious attempt to install the system developed by Mr. Taylor, but I do know that by a careful study of the work of this department he has raised the standard of efficiency so that every man that I saw was employed continuously in producing a very high class of work with a rapidity that was astonishing, and by methods which the average shop foreman would say were impossible. In conversation, Mr. Norton emphasized the necessity of a careful study of shop problems and stated that such problems were worthy of attention from the most highly trained engineers. Although he never once used the term "scientific," it was quite evident that his study was scientific in the best sense of that term, and that no single problem which had presented itself in his grinding department ever escaped a most thorough and searching investigation. I shall always remember this department of Mr. Norton's work as one of the finest examples I have ever seen of excellent management, and also I shall always remember the type of employee which I saw in the department as a representative of the very finest type of the American mechanic. Every man seemed to be a man of unusual intelligence and skill and seemed to be putting into his work that indefinable something, which for the lack of a better term we designate as "brains."

A third matter which attracted my attention was the fact that Mr. Norton seemed to be personally acquainted with every man working in that department; seemed to know their especial abilities and the work for which they were best fitted, and seemed to take great interest in seeing that each man was doing the kind of work for which he could realize the highest pay. So far from adopting the attitude of the average employer, who is inclined to think it a matter of good business policy if he can drive a sharp bargain with his men, and obtain a day's work for a minimum wage, Mr. Norton spoke with pride of the unusual earnings of several of his men who were working under a premium system.

AN EXAMPLE OF INEFFICIENT MANAGEMENT

At another time I visited a concern in which it seemed to me that the majority of the men were doing absolutely nothing that was useful. This concern was one of the largest ship building yards of the Atlantic coast. I had no opportunity to talk with any of those responsible for its management and therefore cannot say what attitude they adopted toward various questions of administration. There did, however, seem to be a dearth of foremen, and as in the time of the Judges in Israel, " every man did that which was right in the sight of his own eyes." I remember seeing one man who was engaged in chipping a plate with a pneumatic hammer, and he had two assistants whose duty seemed to be to drag the air hose after them and carry his hammer as he went from place to place. At another place I saw a man measuring a plate and marking upon it an opening which was to be made in a bulkhead, with five or six workmen lounging around him doing nothing. Most of the work of the establishment seemed to be conducted in that manner, and altogether, it was the most disgusting exhibition of shiftless management that I have ever seen in my life. The matter was so apparent that several students who were with me at the time called my attention to it, although they were men unaccustomed to shop administration and most of them were men totally unfamiliar with methods of shop work.

ADMINISTRATION OF AVERAGE AMERICAN SHOP

The administration of the average American shop is a mean between the slipshod methods of the shipyard and the careful and efficient methods of the Norton Grinding Co. In such a shop such obvious inefficiency as I have described in the case of the shipyard would be promptly squelched. On the other hand, in such a shop, careful investigation will usually show very great inefficiency in many departments although such inefficiency is not at first obvious. This inefficiency is due to a variety of causes. It may be that work is slack and the workmen are " nursing their jobs " in order to avoid discharge. It may be that they are prolonging an easy and agreeable task in order to avoid being assigned to a more difficult and disagreeable one. It may be that illness or unsanitary shop conditions have deprived the workman of a measure of his usual energy and ability. In many shops, inefficiency has nothing to do with the workmen, but is entirely chargeable to the management. All of the men appear to be busily employed and the work to be carefully conducted, but at the same time, the type of machines used, the sequence of operations employed, the conduct of the toolroom, or any one of a dozen different things for which the management is or should be directly responsible, greatly reduces the efficiency of the shop.

The writer was once employed by a firm that manufactured small steam engines for the oil trade. Each of these engines was equipped with two flywheels weighing about 600 pounds apiece and the only machine work done upon the wheels consisted in boring the hub, reaming it, and cutting the keyway. I was employed to bore the hubs, which was done upon a homemade machine having a stationary spindle and a revolving table. There was a crane which was used to place the wheels upon the table, but before the wheels could be lifted by the crane, they had to be brought about 500 feet from that part of the yard in which they were stored after being cast. I was instructed to get another apprentice who was named Gus, to help me roll them from the storage yard to a point under the crane. During this time, both my machine and Gus's machine were idle, since they were of a character which required constant attention. This job had to be done several times a day, and I doubt if those two machines were running more than half the time.

As I remember conditions in that shop, I can see that there were endless possibilities of increasing the output by improving the methods of management. Nevertheless, to one who is not in the habit of thinking about the possibilities in this line, the shop appeared to be busy and well managed. It was conducted by a foreman who had an excellent reputation and who was supposed to know " how to get out the work." He was a man of considerable experience and knew about how much time certain work would take when done by the average machinist in the average way. Most shops would have considered him a valuable acquisition, and in a great many shops he would have introduced notable improvements. The ship building company I have already described would have been fortunate had he taken their affairs in hand, but any department managed by him would have made a sorry showing alongside of the grinding department of the Norton Grinding Co. He employed the usual methods of conventional management, that is, he allowed his men to choose their own methods of doing work, and then eliminated those men or those methods which were obviously incompetent or inefficient. He was not at all versed in the scientific plan of finding the methods of greatest efficiency, and of applying them in the administration of his department.

MISAPPREHENSION OF PRINCIPLES OF SCIENTIFIC MANAGEMENT

I have heard a good many men say, in regard to scientific management, that they have managed their affairs scientifically without knowing that they were scientific. However, when I have come to talk over the matter at length with them, I find that what they mean is that some of the inefficiencies not usually obvious had become apparent to them, and that they had adopted some of the methods of scientific management in attempting to eliminate the inefficiencies which had come to their attention. This is a very different matter from installing a system of scientific management, although the efficiency of a good many plants had been greatly increased in this manner. However, the men of whom I speak do not understand what scientific management is. They think that scientific management is a collection of best methods, that it necessarily involves the use of certain kinds of blanks and records, or that it is a form of organization, a method of wage payment, or something of that kind. Of course such things are employed in scientific management, but they are only the tools which it uses, and just as a carpenter will change his tools for different kinds of work, so scientific management will adopt different methods, different forms, or different plans of organization, as conditions change.

A great deal of harm is likely to come from the unintelligent employment of some of the methods of scientific management by such men, even when they are acting in the best of faith. The introduction of some of the methods will often cause antagonism among workmen, and they will sometimes prove inefficient under new conditions. In either case scientific management is blamed for the failure, when, as a matter of fact, scientific management would probably have employed other methods under the given conditions. Scientific management must not be confounded with its forms or its methods, just as a man must not be confounded with his clothes, or a religious creed with its form of church organization.

METHODS UNDER DIFFERENT TYPES OF MANAGEMENT

It will help us in our consideration of different types of management, if we take a concrete example and note the differences of the several types, as they appear in the example. Let us suppose that a piece of lathe work is to be done, such, for instance, as the turning of a crankshaft. In the conventional type of management the foreman will assign such a job as this to the first man having a vacant machine in which it can be conveniently performed. Systematic management will usually do the same thing. Scientific management, on the other hand, will assign the piece of work to that machine in which it can best be performed.

Having received the work, under conventional management, the workman will determine the plan of procedure, will choose and grind his own tools, and will proceed to work, using those feeds, cuts, and speeds which he thinks will be the most satisfactory. In case the workman is receiving day wages, the pace of the work will depend upon the foreman. As the foreman goes about the shop, he will occasionally take notice of the condition of the work and the way in which it is being performed. If the workman is obviously incompetent or inefficient, the foreman will instruct, reprimand, or discharge him, as his judgment will warrant. On the other hand, if the work appears to the foreman to be going forward at a reasonable pace, nothing will be done.

In case the workman is being paid by some piece work or premium plan, he will be anxious to earn as large a wage as possible and therefore will attempt to determine the best cuts, feeds, and speeds for the work in hand. There are two methods open to him for doing this. One is to guess at the best conditions and the other is to experiment until he has determined them. The first method, of course, leaves much to be desired. The second method is open to the objection that it takes a considerable number of experiments to determine the best conditions of work, even when the experiments are confined to the performance of a certain job on a certain machine. The workman is rarely, if ever, able to devote the necessary time to such experiments, and he has not the training which would enable him to properly perform and record them. With the facilities which he usually has at hand, it is impossible for the average workman to do any more than gradually improve his performance by careful attention to his methods of work.

Conventional management determines the time required to do a piece of work, or the piece rate to be paid for it by one of two methods. The first method is for the foreman or some other experienced person to guess at the time required to do the work. The other is to put a capable and conscientious workman at the work and see how long it will take him to do it. Of course the guess of the foreman is about as good as the guess of the average drummer would be if he tried to estimate the population of a village while he was riding through it on a train. The other method of allowing a pace maker to determine the piece rate is a better one. Since, however, the pace maker usually does not have the opportunity of making a careful study of the best methods of performing the work, his time allowance will usually be too large.

Systematic management, like conventional management, leaves the method of performing the work entirely to the workmen. It does not, however, leave the question of the proper pace to the foreman. The records of previous performances have established a pace and the management can readily determine whether or not the work is being conducted at the best pace of which there is previous record. If it is not, the foreman is notified and the workman is obliged to increase his pace. He may do this in one of two ways. He may experiment in order to determine the possibilities of the work, or he may go to some one who knows more about it than he does for assistance and instructions in regard to feed, cuts, speeds, and methods. In either case he is nagged into bringing up his pace to that of the previous man, and in this way the production is kept up to the best previous record.

Under scientific management, the sequence of operations, the cuts, feeds, and speeds, the tools and appliances, and the methods of work are determined by the management and not by the workman. Before the work is commenced, a specialist considers all the possible methods of doing the work and after carefully analyzing them determines which of these methods are the best. Having fixed upon the methods of work, a time allowance is then established for each operation. A typewritten or blueprinted instruction sheet is then prepared which informs the workman exactly what he must do, and how long it should take him to do it. Instead of grinding his own tools, he receives a supply of properly formed and ground tools. Instead of depending upon the foreman or upon previous records for establishing the pace of work, the time required to perform each of the several operations is exactly known. The whole series of operations has been subjected to a careful analysis, every possible variation has been considered, and the methods developed are not only good ones, but are the best possible ones, considering the limitations of that particular shop.

In order to accomplish the best results, not only must the workman receive an instruction sheet, but he must be shown how to perform many operations. One of the officers of administration is, therefore, the teaching foreman,[1] who makes it his business to instruct the men in the proper ways of doing work and who is always ready to come to the aid of those men who are unable to perform their tasks in the allotted time.

In order to encourage the workman to follow the proper methods of work and to perform his task in the allotted time, a piece work, premium, or bonus plan is adopted for the payment of wages. The plan which seems to give the most satisfaction is known as the Gantt bonus plan. This consists in paying the man a certain definite percentage of his daily wages as a premium whenever he performs his task within the allotted time. If his task, for instance, consists of ten pieces a day, and he

[1] This is the foreman called by Mr. Taylor "the speed boss," because the proper speed of the machine is one of the things in which it is his business to instruct the workmen. — Ed.

succeeds in making ten or more pieces, he will receive from twenty to sixty per cent additional wages as a premium. In case he produces less than ten pieces, he receives the regular day wages, but no premium. A man's earnings are computed each day and he knows on the morning of the following day whether or not he has earned the premium. If he has not, it is the duty of the teaching foreman to go over his work with him and instruct him in those points in which he may be deficient. In order to make sure that this teaching is thorough and effective the teacher receives as a bonus a fraction of the bonus[1] earned by his workmen and in case all of his workmen earn bonuses, the teacher receives an extra bonus. It will readily be seen that with such a system of wage payment, thorough instruction and coöperation are the invariable order of the day, and that the foreman as well as the workmen are always on the lookout to see that the tools, machines, and stock are all in perfect condition.

Not only does the man receive adequate instructions, and a reward for obeying these instructions, but he is offered every reasonable facility for doing his work quickly and well. He does not have to spend his time hanging around the smithy or the tool room getting the things that may be needed for his work. He spends no time repairing his machine, taking up the belts, or fixing the tools supplied to him. The management makes it its duty to see that nothing hinders him in his work so that his entire time and attention may be devoted to the performance of, and not to the preparation for, that work. This requires that certain assistants shall perform tasks which conventional management usually delegates to the workman himself.

COLLECTING DATA NECESSARY FOR SCIENTIFIC MANAGEMENT

It will be apparent from the foregoing, that instead of depending upon judgment, scientific management depends upon knowledge, in its task of administration. Judgment is the instinctive and subconscious association of impressions derived from previous

[1] This does not mean that the teacher's bonus is deducted from that of the workmen, but that it is a very much smaller percentage, the aggregate amount of which depends upon the number of workmen whom the instructor has brought up to the bonus-earning point. — ED.

experience. When a man's experiences are wide, his impressions of them are correct, and his memory is good, his judgment will be good. But even the best judgment falls far short of knowledge, and any system of administration based on judgment alone must fall short of scientific management. Judgment will always have its place in any system of administration for two reasons, firstly because knowledge cannot always be obtained, and secondly because it may sometimes cost more to obtain it than the knowledge is worth. In either case judgment is valuable, if not absolutely necessary. But at the best, judgment is only a guess and not to be relied upon if accurate information is available. Not only does scientific management depend upon knowledge, but this knowledge is carefully and systematically collected and the data so obtained are classified and digested until the knowledge is instantly available whenever a problem is presented to the management. Back of the form of organization is a knowledge of the needs and the work of the plant. Back of the plan of wage payment is a knowledge of pyschology and sociology. Back of the instruction sheet is a knowledge of the sciences of cutting metals and of handling work. As examples of the way in which such knowledge is obtained, let us take the two subjects last mentioned, and see what scientific management has done to develop the sciences of cutting metals and of handling work.

Most readers of these articles are doubtless familiar with the paper of Mr. F. W. Taylor on the art of cutting metals, which was published in abstract in many of the technical magazines shortly after it was delivered, in 1906. The work described in this paper is probably the best example of the scientific study of methods of manufacture which has ever been made. Mr. Taylor and his associates at the Midvale and Bethlehem steel companies were engaged in the work for nearly twenty-six years, and during that time made many notable discoveries in the line of their work.[1] One of the most important of these was the discovery of high-speed steel; which is, at a very conservative estimate, worth fifty million dollars per year to the machine

[1] See introduction to F. W. Taylor's "The Art of Cutting Metals" in this volume, page 242. — ED.

industry of this country. Other no less important but less spectacular results were the discovery of the best forms for cutting tools, the invention of a slide rule for the determination of proper cutting speeds, and the resulting developments in the form, rigidity, and power of machine tools.

In making this investigation suitable machines were prepared and after establishing certain standards in regard to the kind of material to be cut, the form and chemical composition of the cutting tools, and the length of time which the tools must run without regrinding, a very elaborate series of tests was made. The object of these tests was to determine the maximum permissible speed of cutting with different feeds, depths of cut, kinds of tool steel, forms of tools, classes of material, and conditions of work. There were in all twelve conditions affecting the cutting speed, each of which could be varied. Some of these could be varied over a very wide range, and every time one of the conditions was altered a large number of experiments was necessary in order to determine the permissible cutting speed. It is obvious that in such a complicated problem as this, thousands of experiments were necessary before it could be solved. As fast as experimental data were collected, the results were worked up in order to determine the mathematical laws governing the cutting of metals. Since these laws were found to be extremely complicated, and since, if the work was to be practical, quick and simple methods of solution had to be devised, a great deal of time and effort was spent in devising methods for determining the proper cutting speeds for any given conditions. Finally after many years of work, a slide rule was invented which gave a quick and accurate solution of the problem.[1]

This investigation was probably the most important investigation of the kind ever attempted. It was very thorough, requiring a period of twenty-six years for its completion. The total cost is stated to have been $800,000. The results, in which every metal working shop in the country has shared, are unquestionably worth one hundred million dollars a year. Hardly one manager

[1] See Mr. C. G. Barth's "Slide Rules for the Machine Shop as a Part of the Taylor System of Management," in this volume, page 405. — Ed.

out of one hundred, probably not one mechanic out of a thousand, realizes the immense value and scope of the improvements resulting from this investigation. They rank in importance with the development of the steam engine, the railroad and the printing press. There are equally great opportunities for a dozen, possibly one hundred investigations of like character in other industries. It is to be hoped that they will be soon commenced and that they will be prosecuted with the same energy, tenacity and intelligence with which this investigation was so greatly marked.

MOTION STUDY AND ANALYSIS

The method employed in determining the best way to handle work is known as "motion study." Motion study is almost a science in itself, and is really a branch of applied psychology. Motion study is not peculiar to scientific management, but has long been utilized by athletes in their endeavor to improve athletic records. A high jumper, for instance, will carefully train himself to do his work in a certain way, taking a certain number of steps in running up to the bar, throwing his limbs and body in a certain position as he jumps over the bar, and endeavoring in every way to develop that smoothness and machine-like precision of action which characterizes what he terms "form." The hurdler does the same thing, day after day making trial of different methods of running and jumping, timing himself by the stop watch, in order to achieve the most perfect form.

The same sort of study can be employed to advantage in training workmen to perform their tasks, when the tasks are repetitive in character. There is, however, one very great difference between motion study for the athlete and for the workman. Whereas the athlete strives to perform a task which taxes his strength and endurance to the limit, the workman strives to develop that form which will enable him to perform his task quickly and with a minimum of fatigue. In the case of the athlete, he is striving to excel for one supreme moment. The workman, on the other hand, must be trained to repeat his task, day after day, month after month, year after year, without injury to his strength or his health, because only in that manner can the industry in which he is engaged reach its maximum prosperity. It takes a more carefully trained observer and a far better understanding of men and their physical capabilities to train a workman to do a task quickly and well without over-exertion, than it does to train an athlete to perform his task quickly and well, where the question of over-exertion does not come in.

Any one who has ever had anything to do with athletics understands how impossible it is for a man without training to compete with the trained athlete. Just as it would be impossible for the average healthy and vigorous man to enter an athletic contest and do creditable work in competition with trained athletes, so it is impossible for the average workman to go into a shop and accomplish a creditable amount of work, in competition with a workman who has been properly trained after a motion study has been made of his task. In the same way, just as it is impossible for the average man who likes to look at the stars, to predict the time of an eclipse or the future configuration of the heavens, so it is impossible for the average machinist to compete with the trained engineer who has at hand a slide rule which will tell him exactly the cuts, feeds and speeds which it is possible to employ with a given class of material and a given machine. We find it advisable to employ designing engineers who have spent years in studying the strength of materials and the sciences upon which engineering depends. It is equally advisable to employ another class of engineers who will study the principles of management, and methods of doing work.

So far we have only touched on two points in regard to the turning of our crankshaft, namely motion study and the science of cutting metals. There are a dozen other branches of science involved in the direction of the shop, all of which are used by scientific management in furthering administration. When we consider these things, it becomes apparent that in many industries the introduction of scientific management will completely revolutionize methods of work, methods of administration, and even methods of selling the product and of financing the industry.

It will be seen from what has just been said that scientific management is by no means a simple matter, that it requires forethought and care in its application, and that, above all things, it requires the scientific spirit in order to make it successful. It will also be apparent to every one that, while scientific management will very probably greatly increase the output per man or per machine, the staff which it requires for the planning of the work, for the conducting of experiments, and for keeping workmen supplied with material and tools will be quite an expensive one. The question of whether or not scientific management is profitable, and therefore practicable, will hinge upon the question of whether the savings which scientific management will effect will pay for the staff which it is necessary to maintain. In my opinion, the savings will usually be more than sufficient to pay for the extra cost of scientific management, although sometimes they will not. The application of all of the methods and machinery of scientific management to the pattern shop, where every job is different and where the principal part of the work consists in planning rather than in executing, will not usually be a success. On the other hand, where scientific management is applied to repetitive work, there is no question but what the cost of maintaining the staff will be but a very small fraction of the savings which will result.

II

Causes of Industrial Inefficiency

So far this article has considered only the broad aspects of industrial administration. In order to get a better idea of the objects of scientific management, the methods which it is likely to adopt, and the obstacles which it must overcome, I propose to classify and describe some of the causes of inefficiency in our industrial life. In studying the causes of inefficiency we will discover the remedies which a proper system of administration should apply, and develop some of the principles underlying scientific management. I do not claim that all the faults which I will describe are prevalent in every industrial plant not under scientific management. I will admit that most of them can be eliminated without the complete adoption of scientific management. I do know, however, that they are astonishingly prevalent in our industrial life, and that neither conventional nor systematic management has succeeded in uprooting them.

The causes of inefficiency may be divided into three classes: The first are those causes which are chargeable primarily to the employer, the second those which are chargeable primarily to the workmen, and the third those which are chargeable primarily to our political and industrial system.

Those causes of inefficiency which are chargeable primarily to the employer may, in turn, be divided into two classes. Those of the first class arise from a lack of knowledge. They can be remedied by showing the management the possibilities of better methods. Those of the second class arise out of moral defects on the part of the employer, and will require more than a change in the system of management or full information of the conditions of the plant in order to eliminate them.

MENTAL LAZINESS

The first and most prolific source of inefficiency is mental laziness. Most of us dislike to think. While a good many of us will devote a spare hour now and then to the consideration of some interesting subject, no man will, if he can avoid it, devote two hours a day, not to mention eight hours a day, to the task of devising and comparing methods of work. That kind of thing is entirely too strenuous to suit the average officer of administration. In the average plant, each officer places upon the shoulders of his underlings the burden of detail for which he himself ought to be responsible. When work is to be done, the manager "puts it up" to the superintendent. The superintendent, in turn, puts it up to the foreman, the foreman to the gang boss, and the gang boss to the workman. Upon the workman devolves the task of devising the methods and of planning the details of the work. Now as I will show later, the workman is no fonder of thinking than the management, and performs his task in that way which involves a minimum of mental effort. He is not to be blamed for so doing, because he has merely followed the example of the management. It is the duty of the management and not of the men to study the work, to discover the most efficient methods, and instruct the men in those methods. When, because of lack of instruction, the men fail to perform their work in the most efficient manner, it is the fault of the management and not of the workmen. Conventional management is fundamentally wrong, in that it compels the workmen to originate the methods, and leaves to the management only the task of criticism.

When the management of an industry is reproached for laziness in not properly directing the workmen, the officers of administration will usually reply to this effect: "These workmen which we hire are supposed to be competent men. They are experts in machine molding, tool dressing, lathe work, or whatever it is that we hire them to do. They have devoted their lives to these lines of work, and know a great deal more about it than we do. When a man receives a job, he can devote his entire attention to that one job. His task is easy, because he has to think of but one thing at a time. If we devised the methods of work, we would have a thousand jobs to figure on each day. They could not receive the same amount of attention that they get now, nor would that attention be as satisfactory, since we are not experts, and the men are. When you ask us to direct the workmen in the details of their work, you are demanding of us an overwhelming and impossible task."

In answer to this argument, it is only necessary to say: First, while the workmen are usually much more capable than the management, this is due to the lamentable ignorance of the management, and not to the extraordinary knowledge of the workmen. It is practicable for the management to acquire and apply knowledge which it is impossible for the workman to have. Second, many shops that are eminently successful do direct all of the acts of their workmen. Third, when the workmen devise the methods of doing work, they are handicapped by being obliged to use such tools and machines as the management provides, while, when the management devises the methods, they can and will secure the proper tools and machines for doing the work.

PREJUDICE AGAINST SO-CALLED NON-PRODUCTIVE LABOR

A second source of inefficiency is a dislike on the part of most managers to employ a considerable executive staff to direct the efforts of their workmen. The management balks at such a staff, and claims that " non-productive " labor is a necessary evil if you have to employ it, and an unnecessary evil if you can do without it. In the old days draftsmen were regarded as an unnecessary evil, and the designing was done by rule-of-thumb and the head patternmaker. Experience has shown that *Johnny Pencilpusher* is not an evil, nor is he unnecessary, and that it pays to employ him. Accordingly he is now classed as " productive " and not as " non-productive " labor. The men who direct the work of the shop are just as necessary as the men who make the designs, yet it is difficult to persuade the average manager that a large executive staff is desirable even when you can show him that a gain will result from its employment. The attitude toward such a staff is well shown by the name " non-productive," so often applied to this class of labor. The labor of the planning department is just as truly productive as the labor of the drafting department, the machine department, or the erecting department. A new attitude in regard to the employment of indirect labor is a pre-requisite to greater efficiency in many of our shops.

TIMIDITY OF CAPITAL

A third fault of management is timidity. Capital seems to be ruled by fear quite as often as by judgment. Men dislike to risk their money in something which they feel is not absolutely sure to bring adequate returns. They especially dislike to risk money in any investment which is of such a character that they cannot recover the principal in case they decide to give up the enterprise, even though adequate returns are almost certain. Managers often hesitate to spend money for new tools or equipment until other firms have tried the tools or equipment and found them to be successful.

Probably one of the best examples of this is the difficulty which Mr. George Corliss had in selling his engines at a reasonable price, when they were first brought out. It will be remembered that in some cases he had to take for his pay the value of the coal which his engine could save in a given period of time, and was under bonds to take out his engine and reinstall the old one in case the purchaser decided that the new engine was unsatisfactory. Just as Mr. Corliss' customers were fearful of spending money for an improved type of engine, and insisted on making a contract which was, in reality, unfavorable to themselves, so the present-day employer is fearful of assuming the expense incident to proper management, even though it can be shown that great gains ought to be realized from proper administration.

LACK OF FORESIGHT

This brings us to a fourth fault of management, which is lack of foresight. The management, in performing the work of today, fails to make allowance for the needs of next week, or the growth of next year. Plants grow in haphazard fashion. Equipment is added without making plans for the future. No attempt is made to insure that there will always be a corps of trained workmen and a staff of able foremen. The lack of definite and far-reaching plans for future work is not felt at the time that such plans should be made, but is felt later.

MENTAL INERTIA AND LACK OF ADAPTABILITY

A fifth fault of management is one which may best be described as "mental inertia." Managers tend to follow methods which have been satisfactory in the past, but which changing conditions have made unsatisfactory for present requirements. Whenever a new invention of any importance is introduced into a shop the conditions of work are greatly altered. The introduction of high-speed steel is a case in point. When the time required for machining work is cut down to a third of that formerly required, the amount of crane service for a given number of machines is trebled. The foundry and forge shops must be made very much larger in order to furnish the stock required by the machine shop. The amount of storage room required for stock and for finished product is greatly increased. The relative importance of different items of cost is radically altered, and the nature of the problems of administration is greatly changed. Notwithstanding these changes, we will find that in most cases the management will attempt to get along with the least possible change in equipment, and in methods of work and administration. Many men resist change simply because it is change, in spite of the fact that the change may be desirable.

One of the best examples that comes to mind of the mental inertia that prevents the adoption of new ideas is the general disregard of Mr. Taylor's discovery that the use of a heavy stream of water at the cutting point of a roughing tool increases the permissible speed of cutting by forty per cent. If the machines of a shop are engaged on roughing work for one-third of the time, by the use of such a stream of water their output will be increased by thirteen per cent. In a shop in which 100 men are employed on machine work, this will mean a reduction in the cost of machining of about $20,000 per year. To install a system for distributing soda water to all the machines in such a shop, and for returning and purifying the water, will certainly not cost more than $20,000, yet, so far as the writer is aware, there is only one shop in which such a system has been installed, even though it would unquestionably pay one hundred per cent on the investment. This is an example of bad management arising from mental inertia, which occurs in almost every shop. When the subject is brought up in any plant, the management fortifies itself in its obstinate attitude, by advancing as arguments statements which are untrue, for instance, that the system costs more than it is worth, that the soda water destroys the machines, or that it is always giving trouble, Were the management to give the matter proper study, however, it would find that practical experience has demonstrated that the benefits realized are so great that their shops cannot afford to operate in any other way.

LACK OF STUDY OF THE INDUSTRY

A sixth and probably one of the greatest of all causes of inefficiency is the fact that the management very seldom makes a careful study of the industry. In the few cases where a careful study is made, it is usually done for the purpose of improving the materials used or the quality of the output, or increasing the amount of work turned out by the use of a given method.

It is of equal or even greater importance that the methods themselves should receive the same careful study. Probably the best example of a scientific study of methods of manufacture is the work of Mr. Taylor on the art of cutting metals, to which reference has already been made. It is probable that a similar study of methods would result in equally important developments in other lines of industry. Such studies are not made for three reasons. In the first place, managers do not realize the need of such studies nor the advances which are possible. In the second place, very few men are capable of making such studies. In the third place, inertia opposes the changes which would result from such studies, and timidity hesitates to expend the money necessary to carry them out. Very few managers would have the courage to commence an investigation whose final cost would be $800,000 and which would take twenty-six years for its completion, and while the management of some very large industries might be willing to take a chance on an investigation of this kind, even the most sanguine would deride the possibility of such an investigation producing such valuable and far-reaching results as have followed from Mr. Taylor's experiments. When all is said and done, it will be found that most managers want some one else to do the experimenting, feeling that by so doing they can participate in the profits of such work without sharing its expenses.

SYSTEMS OF REWARDING LABOR

A seventh source of inefficiency in many industrial plants is the system of wage payment adopted. It would be hard to devise wage systems better calculated to limit efficiency than the two which are in most common use; namely, the day wage plan, and the piece work plan with frequent cuts. Under the day work plan, the man receives no reward for his efficiency, he is instead punished for inefficiency. This is a method which is fundamentally wrong, and only to be employed when no other method is possible. When a man receives day wages, he is paid for the time which he spends at his work. The first question which arises in connection with this system of wage payment is: What wages ought a man to get? The answer is he ought to get all he can. He is selling a commodity, labor. He asks for it the highest price he can get, and is justified in so doing. His labor is measured by time and the value of the labor performed in a given time has nothing to do with the payment which he receives. The only thing which limits him is the fact that if he does not do a satisfactory amount of work, he will be discharged. What constitutes a satisfactory amount of work, neither he nor anybody else knows. The whole thing works out very much as it would if a man when buying a quart of milk were to insist simply that there be some milk in the quart measure, and the matter of how much milk there was to be in the measure should be left with the milk-man, with the understanding that the milk-man would lose his customer in case the amount of milk was not satisfactory to the purchaser.

When you discuss with the average workman the question of proper wages and the proper amount of work to be done in a day, he will tell you that his motto is "a fair day's work for a fair day's pay." Different men, however, have very different ideas as to the amount of work which constitutes a fair day's work. Some employers think that it is all the workmen can possibly accomplish. Some workmen think it is the least that they can accomplish and still not get fired. Most workmen think it is work they can do when working steadily at the gait that habit and temperament have fixed in their cases. Most employers think it is the amount of work which their most honest and industrious employee normally does. When there is such a great diversity of opinion as to what constitutes a fair day's work, it will naturally be seen that there will be great diversities in the efficiencies of different men and different shops.

When a piece work plan is adopted, the management usually knows very little about the possibilities of the work. If the management fixes what the men think to be a reasonable piece rate, the men will soon so increase their output that they will be making exorbitant wages. The management will then cut the piece rate, and after the men have experienced a series of cuts as a result of successive increases in efficiency, they will discover that the management does not propose to pay them more than a certain amount of money, and will work just hard enough to secure a trifle less than the maximum amount they can secure without experiencing a cut.

If, on the other hand, a proper piece rate is established in the first place (*i. e.*, one by which the men can earn fifty per cent to one hundred per cent more than a regular day's wages when they have reached their best efficiency), the men will believe that it is impossible to earn reasonable wages under the proposed piece rate, and will decline to accept it.

"HOLIER THAN THOU" SPIRIT OF SOME EMPLOYERS

An eighth cause of inefficiency is one which is happily becoming less frequent. It is a disposition on the part of some employers to regard their workmen as being of a lower order of humanity than themselves. I have talked with such men on more than one occasion. Among their associates they were highly regarded for their kindness of heart, but I have heard them speak of their workmen as "beasts" and "ignorant brutes." No man who regards his employees in that light can be persuaded to adopt scientific management nor can he bring the efficiency of his plant to a high standard, because such feelings will unconsciously affect his attitude in dealing with his employees, arouse their antagonism, and destroy that feeling of coöperation which is the essential basis of high efficiency.

On the other hand, even though the employees of such a man are ready and anxious to coöperate with him, his attitude will prevent him from doing many things which would utilize such potential coöperation to advantage.

AVARICE OF THE MANAGEMENT

The last source of inefficiency of which I will speak is avarice on the part of the management. Avarice reduces wages, cuts piece rates, purchases inferior materials and equipment, employs unskilled labor, skimps on supplies and makes unjust exactions of its employees. Avarice refuses to expend money for the collection of information, for increasing the facilities of work, and for improving the efficiency of administration. Avarice hampers the administrative staff at every point. Avarice is the sin of the board of directors and the stockholders, and not of the superintendent and his staff. Scientific management often requires a large staff of clerks and costly experiments when it is being introduced into a new line of work, and this effectually prevents its adoption by the avaricious employer.

Not only will avarice prevent the adoption of scientific management in a great many cases, but it is also very likely to give scientific management a black eye by adopting some of its methods, without adopting its spirit. An avaricious employer finds himself coming out second best in competition with one who utilizes scientific management. He attempts to appropriate the experience of his competitor in the same spirit in which he imitates his trade-marks, copies his designs, and steals his methods of work. Now while it is possible to imitate a trademark or steal a method, it is not possible to imitate or to steal the scientific habit of mind or the spirit of fair play, which lie at the basis of scientific management. The reward and instruction are just as essential to scientific management as the discovery of a method of work, but the avaricious employer cannot be made to see this. When his neighbor has discovered a method of work better than that which his workmen employ, he will attempt to force his workmen to accomplish the same results without teaching them the new method and without offering them the reward to which they should be entitled, and his attempts will therefore always end in failure. While there is no question but that scientific management will continually discover new and improved methods, processes and materials, and while these improvements will gradually find their way into shops which do not employ scientific management, the extraordinary performances possible under scientific management will never be achieved in the shops of the avaricious employer because knowledge alone will not lead workmen to increase their efficiency.

I have not by any means exhausted the list of causes for inefficiency which arise from faults of the management. It would be as easy to name a hundred as to name nine, but the task is not agreeable. I have endeavored merely to point out the fact that such faults exist, that they can be remedied, and that before scientific management can be applied to an industry, they must be remedied.

CAUSES OF INDUSTRIAL INEFFICIENCY DUE TO THE WORKMEN

While most of the causes which lead to inefficiency are chargeable to bad management, I would not have it inferred that the workmen are free from blame in the matter. I know of many shops in which the blame rests almost wholly on the workmen. In one that I have particularly in mind, the management is keenly alive to the possibilities of improvement. They could today increase their output fifty per cent, and would gladly increase their wages in the same proportion, if the workmen would coöperate with them. Time and again they have attempted to make changes leading to higher efficiency, but in every case the opposition of the workmen was so strenuous that they were convinced that it was the part of wisdom to accept the inevitable and to permit the inefficiency which they deplored. Were they to insist on a change of methods, it is quite likely that labor troubles would force their plant into bankruptcy on account of their limited capital.

THE NATURAL PACE OF WORKMEN

The first source of inefficiency chargeable to the workmen is their disinclination to work at any other than their natural pace. If a man is allowed to work as he pleases he will soon settle down into a certain pace which suits his temperament and nervous organization, and will keep to that pace without very much variation from day to day. I may call this his natural pace. It is perfectly possible for such a man to work very much faster without tiring himself, and if he is properly trained and given adequate inducement, he will adopt the faster pace, and make it his habit to work at that faster rate. I may call this faster pace his proper pace. In order to illustrate the relation of the natural to the proper pace, I would like to compare them to the natural gait which a horse takes when his driver allows him to go at his own free will, and the proper gait which an experienced driver will set for the horse, in order that he may accomplish the best results. A careful and experienced driver will get a great deal more work out of a horse if he urges him to travel at the proper gait. Notwithstanding this, the horse will be no more tired at the end of the day when driven at the proper gait, than he would be had he traveled at his natural gait. The faster gait does not mean undue wear and tear, and the horse will maintain good health and vigor just as long when working for a careful driver who makes him work, as he will if he works for an indifferent driver who allows him to do as he pleases.

A man differs from a horse in two ways. In the first place he cannot be driven, and in the second place, a reward offered him for extra labor must seem to him to be reasonable. It is not difficult to get a man to change his pace if you offer him an adequate reward. If, however, he finds that the reward is not always forthcoming, *i. e.*, if he finds a piece rate being cut or a premium reduced, or if he feels that the reward is inadequate, he will not respond. He cannot be driven by threats of discharge or by fines, and he cannot be coaxed by broken promises or gold bricks.

LACK OF AMBITION

A second source of inefficiency is lack of ambition. While most men will be stimulated by a proper reward, there are some classes of labor which cannot be reached in this way. Some workmen do not accomplish as much or as good work when well paid as they do when poorly paid. In certain sections of the South contractors find that when negro laborers are paid seventy-five cents a day they will work a full week, when paid $1 a day they will lay off one day in the week, and when paid $1.50 a day they will lay off half the time. The reason is that these men are not ambitious. Four dollars and a half a week supplies their needs, and when they have earned that amount they do not care to work any more. It is needless to remark, however, that the average artisan is not of that character. He is ambitious, and invariably responds to a suitable reward, unless he believes that in so doing he is acting against the best interests of himself, or his fellow workmen.

MENTAL LAZINESS OF WORKMEN

A third source of inefficiency lies in the fact that the workman does not like to think any more than the superintendent, the foreman, the manager, or the board of directors. He prefers to work without thinking when it is possible. Few men are physically lazy, but nearly all men are mentally lazy. The only way that a man can work without thinking is to do the job the way in which he or some one else has done it before. When he has to do a new job, he must do some thinking, but usually it will be found that the workman will adopt the method which requires on his part the least mental effort for its origination. Very seldom is the method adopted the best one. In the course of his work, ideas will come to the workman. Sometimes these ideas are good. If the ideas make it easier for him to perform the work, that is, if the new method is in accord with his temperament and habits, the idea is put into practice. If the idea makes it harder for him to work, that is, if it requires him to do something disagreeable or not in accord with his habit, the idea will be rejected. An investigation of methods of work will usually show that men who are physically restless will often adopt difficult and tiresome methods of work on account of their temperament. Men who are physically lazy will adopt easy-going and slipshod methods of doing work. In every case the workman seeks to conform the methods to his temperament, in order that the mental and nervous effort which he must make in accomplishing the work shall be a minimum.

FALLACY OF THE ARGUMENTS AGAINST A GOOD DAY'S WORK

A fourth, and possibly the most prolific source of inefficiency is the belief held by many workmen, and unfortunately, taught by many union officials, that in doing efficient work men are displacing other workmen and lowering wages. There can be no greater economic fallacy than this. One illustration alone will serve to make clear the falsity of the argument that a man who works efficiently reduces wages and the opportunities for labor. Let us suppose that on account of the increased efficiency of the workmen, the cost of making cement is materially reduced, and the output greatly increased. Of course, if the demand for cement were fixed at so many barrels per year, some cement makers would be thrown out of employment, but with the increased output and diminished cost there will come an increased demand for cement, and there will be a greater amount of concrete construction. Instead of reducing the number of men employed, it is quite possible that a larger number of men will be employed in manufacturing cement, and it is certain that a very much larger number of men will be employed in concrete work. If these concrete workers, in turn, become more efficient, cheapening the cost of concrete construction, the use of concrete will be stimulated, more cement makers will be employed, new factories, warehouses and bridges will arise, and finally every branch of industry will be stimulated by the improvement. The workman who increases his output is a benefactor, not alone to his employer, but to every man in the community. His increased efficiency will result in higher wages, and more general prosperity.

The facts in the case are so simple and so easily understood that it is strange to me that every workman does not understand and appreciate them. If all workmen were twice as efficient, the annual value of the products of labor would be twice as great as at present. The products of labor are distributed among the community (somewhat inequitably it is true), and the share which each member of the community can get will be proportional to the total amount to be distributed. Any increase in efficiency means that there will be more goods to be divided, that every one will get a larger share, and that the community will be benefited. It is impossible in an article of this character to go into the subject of economics, but the more the subject is studied, the more clearly the advantages of increased efficiency will be seen. As a matter of fact we can only reach that millennium when poverty, disease and unhappiness will disappear, by the straight and narrow path of increased industrial efficiency, and anything which impedes that efficiency is in reality as great a crime against humanity as the poisoning of a well, or the adulteration of drugs.

ENMITY TO EMPLOYERS

A fifth source of inefficiency chargeable to workmen is a feeling of enmity against their employers. A great many workmen are unable to see the community of interest between the workman and the employer. Some workmen act as if they believed that the two were at war, and that anything done to injure the employer was a benefit to labor.

Now there will always be discussion and bickering between capital and labor as to how the wealth created by their joint effort should be divided. There can, however, be no discussion over the point that each must have a share, and that the amount of wealth which they can divide between them, and the size of the share to which each is entitled, will be great or small according as they are more or less efficient.

Any sensible man can see that the more efficient the workmen are, the more prosperous their employer will be, the better able he will be to extend his works and employ more labor, and the higher wages he will be able to pay. Until all feeling of enmity between capital and labor is replaced by a knowledge of mutual need and appreciation of mutual interest, and a desire for mutual success, not only efficiency, but also prosperity, must suffer.

CAUSES DUE TO POLITICAL AND INDUSTRIAL SYSTEMS

Those sources of inefficiency which arise out of the imperfections of our political and industrial system are just as important as are those due to faults of management or of workmen. Unlike the latter, however, it is impossible for either the management or the workmen to correct the faults we are about to consider. It is not usual to discuss such matters in a technical paper and on that account this phase of industrial administration will be dealt with in the briefest possible manner, confining the discussion to a description of the causes, and not to a discussion of legal remedies. Every one studying the industrial history of this country will be struck with the fact that we have alternate periods of feverish activity and of deadly dulness. In so-called "boom times" factories are run twenty-four hours a day, efficiency and quality of workmanship are sacrificed to output, our railroads are crowded to the limits of their capacity, untrained and inefficient men find ready employment in all trades, ill-considered plans for industrial expansion are hastily carried into effect, inferior and unsatisfactory equipment is eagerly purchased and installed because no other kind is available, and the general efficiency of our industrial system suffers a severe decline.

As a result of this inefficiency a "period of business depression" sets in, men are discharged, plants lie idle, wages fall, men are forced to move at great expense, and to seek new employment for which they are not trained, and again inefficiency is the order of the day. Now there is no reason why these alternations of activity and dulness should occur, except that our methods of conducting business are wrong. Proper laws, proper methods of banking, improved business customs, and a rational development of our natural resources and methods of communication will very nearly eliminate such conditions.

Certain industries, however, are subject to seasonal variations of opportunities for work. Agriculture and the canning industries are examples. Other industries are subject to seasonal variations in the demand for their products. The automobile industry and the manufacture of Christmas goods are examples.

Where the supply of raw materials for an industry is subject to seasonal variations, nothing can be done except that such an industry may be operated in connection with another industry so that the workers and possibly a portion of the plant may be efficiently employed, practically all the time. Where the demand for the products of an industry is subject to seasonal variations, the industry may run steadily throughout the year if an accumulation of stock is permitted. The amount of capital tied up in the stock will usually, in such a case, be less than the capital otherwise tied up in the plant, since a plant which turns out a given product in three months will have to be four times as large as one which turns out the same product in a year, working the same number of hours per day. There is also the possibility of operating such an industry in connection with another industry, possibly of a like character, in such a way that both the plant and the workmen may be efficiently employed throughout the year.

We must all recognize that one of the causes of inefficiency at the present time is the struggle which is going on in the business and political world over the question of whether capital shall be used for the benefit of those who nominally own it, or whether it shall be used for the benefit of the community. Originally the position sanctioned by law was that capital belonged absolutely to the one owning it, and that he might use this capital in any way that he saw fit, except that he might not employ it in levying war on the sovereign, or in committing a criminal act. We are gradually coming to the view that capital must be used for the benefit of the community, and while we believe that the nominal ownership and the detailed administration of industrial enterprise should be left to individuals, we are coming to insist that a business shall be conducted efficiently, that in case the business is not regulated by competition the profits shall be reasonable, and that the methods of making and marketing the products shall be those which will further the well-being and efficiency of the community as a whole, rather than the profits and self-satisfaction of the owner of the business. While we are engaged in this process of changing the fundamental principles of law and of business, we must expect that inefficiency will be more or less the order of the day.

One of the economic sins of the present day which is very effective in destroying efficiency, is foolish and wasteful competition. The construction of parallel and competing lines of railway when one line is adequate to serve the traffic is a case in point. The installation of two telephone companies in the same city, of competing street car and electric railway lines, the duplication of generation and distribution plants by two electric power companies, and competition in other so-called "natural monopolies" are other examples. There are certain kinds of industrial work in which competition is undesirable and inevitably leads to inefficiency, and laws which permit or encourage such competition place a premium upon such inefficiency.

Another cause of inefficiency is frequent and sudden changes in laws, customs, fashions, and social conditions. For instance, a bounty, subsidy, or extraordinary high tariff may cause the factories and workmen of an industry to be transferred from Europe to America. This transfer means a considerable temporary loss, and in case American conditions are not naturally favorable to the development of the industry, it causes a permanent loss. A few years later the abolition of the tariff or the bounty may cause the plant to be re-transferred to Europe and the workmen to be thrown out of employment, with a further loss. Similarly, a change in the direction or amount of traffic in a given district, the development of new resources, the sudden growth or decline of a transient industry and many similar things may affect the efficiency of a given plant, or even a whole industry. Often these changes are entirely beyond human control, or are incident to increased efficiencies in other and more important lines.

III

Consideration of the Most Important Objections to Scientific Management

Enough has been said to show that laws and economic conditions have a very great effect upon our industries and the efficiency with which they are conducted. Changes in the law which decrease efficiency are usually objectionable and changes are usually more far-reaching and important than most men believe to be possible. While the engineer usually considers such matters to lie entirely outside his work, yet they affect it so vitally that he will before long be compelled to give them his attention, and to apply to them the same hard-headed and rigorous analysis that he now gives to the design or construction of a piece of machinery. When he does, the law maker will regard his efforts skeptically, the financier will regard him as a meddlesome bungler, and most men will regard him as a gross materialist without proper regard for the higher things of life.

In the same way that we have previously classified and examined the sources of industrial inefficiency, let us classify and examine the objections which may be raised against scientific management. These objections come from three sources, the employer, the employee and the public.

OBJECTIONS OF EMPLOYERS TO SCIENTIFIC MANAGEMENT

Taking first the objections raised by the employer, they usually arise either from a misunderstanding of what scientific management is or from a misconception of the fundamental principles of industrial administration. The objection most often raised is that scientific management very greatly increases what some men term the "expense burden" and what others term the "overhead charges." This is true and yet it is not an objection to scientific management if it can be shown that the total cost of manufacturing a given product is reduced by thus increasing the overhead charges. The introduction of a drafting room or of a pattern shop into an establishment which has previously purchased such work outside, will increase the overhead charges, but most plants find it cheaper to maintain drafting rooms and pattern shops in spite of this fact. If four men are employed, it is just as well to have one of them constantly engaged in planning the work of the other three, and keeping them supplied with tools and material, as it is to have each one plan his own work and run his own errands.

The question of whether scientific management unduly increases the expense burden is one which can only be answered by experience and in the terms of dollars and cents. If the cost of doing a given piece of work is reduced by scientific management, the question of the ratio of the overhead to the direct charges is of no consequence. If, on the other hand, the cost is increased by scientific management no other argument is necessary in order to condemn the system, and the ratio of the direct and indirect expenses is a matter of purely academic interest.

While some employers are willing to admit that the cost of manufacture is reduced when scientific management is employed, they advance the argument that while direct labor may be discharged when it is not employed, the men in the planning department cannot be discharged without destroying the efficiency of their organization, and so must be retained at considerable expense during periods of industrial depression. Similarly, while the wage cost is cut off entirely when men are discharged, the extra fixed charges upon the larger plant usually called for by scientific management do not cease when times are slack, and that, therefore, in those industries which are particularly subject to periods of depression, scientific management will be a failure, although during periods of prosperity, it may show a reasonable saving in costs of manufacture. To this objection two answers may be made. First, when scientific management shows a gain after taking account of the periods of depression, it ought to be adopted. Second, if scientific management enables a firm to manufacture more cheaply than competitors, that firm will be able to accumulate a surplus so that it can continue to manufacture and store its product when it would otherwise have to be sold at a loss. Furthermore, it will be able to undersell its competitors, will do a fairly large business in dull times, and will therefore be able to operate its business with less attention to industrial conditions than is given by other firms. If scientific management is able to show a saving at any time, the chances are that it will be able to show a saving all of the time.

A third objection often raised to scientific management is that when a shop is run as systematically as this method of management requires, a sudden change in plans is impossible without seriously disarranging the work, so that the rush order or the special job does not receive the attention which it should. The answer to this objection is that scientific management should contemplate all of the conditions likely to arise in the plant and should provide special means for expediting certain work when that is necessary. If such special means are not provided, the system is imperfect and is not scientific management since it is not adapted to the needs of the particular plant.

A great many objections raised against scientific management come from men who have seen shops in which scientific management has been attempted by managers, superintendents or others, who did not understand what it was. Such men have often attempted to combine scientific management with conventional systems, and while they have sometimes developed improvements, they have often fallen into ludicrous blunders. Such blunders cannot be charged to scientific management, and when it is claimed that scientific management has failed in specific instances, it is well to investigate the case, and see whether the failure is one of scientific management or of unscientific management.

OBJECTIONS OF WORKMEN TO SCIENTIFIC MANAGEMENT — WEARING OUT MEN

On the part of workmen there is considerable objection to scientific management. I believe that it usually arises from an idea that efficiency lowers wages and throws men out of employment. This objection, however, is rarely if ever alleged, but others are sought to take its place. The first one, and the one worthy of most serious consideration, is the objection that under scientific management men are urged and compelled to work at such a pace that their health and vitality suffers. Now it is doubtless true that men can be overworked in certain industries, but it is equally true that it is very difficult to overwork men in most industries unless the hours are unusually long. What is termed overwork is usually a matter of unsanitary laboring or housing conditions or insufficient nourishment. For instance, a man may be compelled to work in a cramped position or exposed to great heat or poisonous vapors, he may be compelled to eat and sleep in a hot and dirty tenement, or his wages may be too small to buy nourishing food. If the adoption of scientific management lengthens the time during which he is exposed to unsanitary conditions, his health will suffer, but this is not a matter of overwork but a matter of industrial sanitation. Scientific management recognizes the fact that workmen are often exposed to unsanitary conditions, but the scientific method is to change the conditions and not to reduce the amount of work required.

When we come to discuss the trades usually carried out under sanitary conditions, and requiring a considerable expenditure of muscular effort, we will find that the amount of effort required to accomplish a given task may be reasonable for some men but unreasonable for others. Whether a task is too severe or not depends on the strength and endurance of the individual workman. Tasks possible for a vigorous man are impossible to one who is ill or weak. Men lacking in strength or vigor are not fitted to engage in certain occupations and they should be transferred to other occupations for which their physical defects do not unfit them. For instance, a man whose strength is unequal to the tasks demanded of a hod carrier or blacksmith helper may be very well fitted to become storekeeper's assistant or to operate a punch press.

In this connection it must be noted that a man is not like a machine, but that the wear and tear of the body are repaired by periods of rest. So long as the degree of exertion required of a man is not such as to produce discomfort when continued for several minutes, and so long as proper rest periods occur at suitable intervals throughout the day, the man will not be overworked, but after becoming accustomed to his task will be able to continue his work week after week without any diminution of vigor. If he is properly nourished and works and lives under sanitary conditions, such a man will be just as vigorous and long-lived as though he were engaged in some less laborious occupation.

As a matter of fact it does not pay to wear men out. If men are caused to work at such a rate that their vigor diminishes, they will in their lifetime do less work than they would had they worked at a slower and less exhausting pace, and both the industry which employs them and the community in which they live will suffer accordingly. On that account we need have no fear that scientific management intends to overwork men, although in isolated instances men may be overworked under scientific management either because they are not fitted to the task to which they are assigned or because the one assigning the task was not experienced enough or careful enough to assign a proper task.

One of Mr. Taylor's early successes was to increase the amount of pig-iron carried by laborers by properly training them for the task. The amount of pig-iron carried after proper training and selection was about forty tons against a previous record of ten tons per day. The first laborer trained for this task was a man named Schmidt, and one of Mr. Taylor's critics thinking the task excessive and severe, very justly inquires, "What became of Schmidt?" Mr. Taylor informs me that Schmidt is at the present time well and hearty and still capable of strenuous tasks and financially much better off then he would be had he not been helped by scientific management.

HARDER WORK WITHOUT CORRESPONDING PAY

The second objection raised by workmen against scientific management is that the men are expected to "work very much harder" without receiving a corresponding increase in pay. Often by the introduction of scientific management, a man's output will be increased three or four fold while his wages will be increased not more than from thirty to sixty per cent. The average workman feels that under such circumstances his wages should be increased in the same proportion as his output. When, however, we come to analyze the matter, we find that the workman's contention is not true and that he ought not to expect his wages to be increased in that proportion.

When a man receives his wages, he is paid for several things. In the first place he is paid for his time. In order to get a grown man of potential value as a workman to come and sit in an office and do nothing for eight hours a day, or even to amuse himself in some manner, it would be necessary to pay him something, and probably it would be hard to find men willing to undertake such work, if it may be called work, for a dollar a day. In the second place he is paid for his physical effort. Work requiring no knowledge or experience and which merely requires physical effort does not usually command very good pay. Of course it commands more pay than does the mere expenditure of time, but certainly the effort which an ordinary laborer puts forth cannot be estimated to command more than 75 cents to $1 a day, and I doubt if the average laborer who receives $2 per day would be willing to take a job at $1.50 per day which did not require any expenditure of effort. A third element for which a man is paid is the ability to receive and understand instructions. A fourth element is skill or dexterity, which enables him to perform a task quickly and well. A fifth element is a knowledge of the details of a trade, which is usually attained by experience and observation.

Let us suppose that a man is engaged in the turning of heavy pieces of steel and that by means of scientific management (*i. e.*, by furnishing him proper tools, by standardizing the material, and by informing him of the proper speeds and feeds to use) his output is increased three fold. The time required is the same as before. That portion of his wages which he receives for time expended should therefore be the same as before. The effort required is three times as great as it was before. Since, however, the most of his time is expended in watching his machine and only a small portion of it in changing tools and work, the pay which he receives for the effort expended is very small, and the increase in pay due to the increased effort is proportionately small, certainly not more than 25 to 30 cents per day. The dexterity which he has, and the knowledge of the details of his trade, are no greater than before, and these elements do not call for any increase in his wages. A larger measure of ability to follow instructions is required, and this element of his pay should be increased. Of the five elements of his pay two require an increase, and three should remain unchanged. Altogether the increase in pay required by the extra effort and by the increased ability to follow instructions is quite modest, and if the man receives thirty or forty per cent increase in wages, he has received all that he can in fairness ask for. The only way in which we can fix a fair rate of pay is by reference to the rates received by other men engaged in substantially similar occupations. The application of scientific management in different industries will result in different increases in efficiency. In some lines a workman's efficiency will be increased only 20 or 30 per cent, while in other lines it may be increased five hundred or even one thousand per cent. If the work done in the two lines is similar, the pay of the workmen is probably nearly equal before the introduction of scientific management, and ought to be equal when they have attained their best efficiency.

Let us take as an example a foundry in which two different molders are engaged, one on light brass molding and the other on heavy iron molding. Let us suppose that each is paid at the rate of forty cents per hour, that the brass molder puts up twenty flasks a day, and that the iron molder puts up two. Let us suppose that as a result of a careful time study it is found that the brass molder can, without tiring himself unduly, put up thirty flasks a day, while the iron molder can put up six. Each man is then working at his best rate, and while it might be possible for him to do a trifle more work, it can only be done at the expense of his physical welfare. If now, the pay of each is increased in proportion to this increased output, it will be seen that the brass molder will get a fifty per cent increase and the iron molder a 20 per cent increase, the brass molder receiving 60 cents per hour, while the iron molder receives twice as much, or $1.20 per hour.

Now, when you come to think over the results of the application of time study in these two cases, it will be plain that if the work of the brass molder was formerly worth 40 cents an hour, that of the iron molder was worth only 20 cents an hour, and it would be highly unjust after the change in conditions had taken place, to pay the iron molder twice as much as the brass molder. In other words, for work requiring substantially the same intelligence, the same effort, and the same training, workmen should receive substantially similar pay, and this pay should be based upon what constitutes a fair wage under the best conditions, and when they have reached their best efficiency.

The same thing which applies in the case of two molders will apply in the case of two different trades in the same industry, or for that matter, in different industries. If the efficiencies of the workmen engaged in two different trades were unequal before the introduction of scientific management, it follows that injustice will be committed if the increase in wages in each trade is made proportional to the increase in output after, in each case, the workmen have attained their best efficiency.

Another way to look at the matter is to treat it as though the workman were selling his labor under the same conditions as any other commodity. Whenever there is a great reduction in the cost of manufacturing a given product, we expect that there will be a corresponding drop in the price, and usually this is true. The cost to the workmen of doing a given piece of work is the cost of living. The fact that he does a much larger amount of work than he did before does not increase his cost of living, and consequently the cost to him of doing a given amount of the work is materially reduced, being in the case we have chosen, only one-third of what it was before. Under such conditions the employer may reasonably expect that there will be a decrease in the labor cost, and while the workmen should expect to get higher wages, the employer expects with reason, to pay a lower price per piece. When the workman has an opportunity to do a larger amount of work without any increase in the cost of living, and to receive for his work a larger wage, he is in exactly the same position as the merchant, who by reducing his price is enabled to sell a larger quantity of goods in a given time, to turn over his capital oftener, and to make a larger profit in the course of a year, although he makes a much smaller profit on each article sold.

Finally, we must consider that when a man's efficiency is increased as a result of the application of scientific management, only a small part of this increase in efficiency is due to his own effort and that the most of it is due to the study and effort of the employer. Accordingly any gain which is realized must be divided between the employer and the employee, and usually with the public in the form of lower prices, in order that the public may absorb the larger output resulting. If the employee is to receive all the benefit resulting from scientific management, which would be the case if wages were increased in proportion to output, then it would be no object for the employer to utilize scientific management and its adoption would be of no advantage to the community. If the employer realizes a third of the gain due to scientific management, he has had his share, and must recognize that the other two-thirds belong respectively to the employer and to the community.

ON BEING NOT REQUIRED TO THINK, BUT TO CARRY OUT INSTRUCTIONS

A third objection often urged by workmen against scientific management is that they are not required to think, but merely to carry out instructions. They feel that when they receive complete instructions as to the method of performing work, it places their work upon a lower plane, transforming them from intelligent workmen into automatons. As one man has expressed it, " I like to think I think, even if I don't think." The answer to this is that Americans have in the past laid undue stress on originality and not enough on ability to follow instructions. If ten men are given explicit instructions as to exactly what to do and how to do it, very seldom will it be that one out of the ten will do exactly as he is told. On the other hand, if ten men are given a puzzle to solve, most of them will succeed within a reasonable time in solving the puzzle. The solution of a puzzle or the origination of a method of work really does not require any higher order of intellect than the exact following of a described method, and is, in the majority of cases, a gift of considerably lower social value.

I have had considerable experience in writing out exact directions informing men in the junior and senior classes of an engineering school, how to perform certain experiments — for instance, how to calibrate a gage. Three men out of five when given the directions for calibrating a gage will read them over and then go to work to calibrate the gage by a method of their own, which is usually incorrect. In the same way, it will be found that when a workman is given a piece of work to do, he will perform the work by a method of his own which is usually incorrect, in that it is not the most efficient method. This brings up the question of whether, for his own amusement, a workman ought to be permitted to adopt inefficient methods of work. When it is put in this blunt manner, every workman will admit that he ought to adopt the most efficient methods of work, and when he realizes that his wages are reduced and his employment endangered if he follows inefficient methods, he will usually be perfectly willing to follow instructions.

The use of instruction cards does not, however, take away from a workman the power of initiative. When a workman succeeds in devising a better method of doing a piece of work than that devised by the planning department, his method will be adopted, and he will receive a reward for devising it. If a workman shows himself capable of devising good methods of work, a place will soon be found for him in the planning department in which he can use his superior ingenuity to his heart's content. Because he has been accustomed to the use of the best methods, he will have a very much better fund of experience to draw upon than a man who has always worked in shops in which the workmen devised their own methods, and on that account his work will be of a superior character.

The use of instruction cards does not prevent a workman from thinking about his work, or from striving to originate new methods, in case he has any originality. Instead, when working from instruction cards, he has constantly before him examples of the best methods of doing work, and his experience is very much superior to that of a man who works in a shop where the workmen devise their own methods.

A man who is minded to do so can advance very much faster in a shop under scientific management, provided he is willing to study and learn. To the intelligent workman such a shop is a trade school, which will help him to a better understanding of his trade, and a chance for larger usefulness.

The argument that scientific management destroys the workman's power of thinking is a fallacy, because it assumes that the only thinking which the workman does is in regard to his work. The higher wages which scientific management involves will bring to the workman opportunities outside of his work which he cannot get otherwise. It will give him money for the purchase of books, for the building of his home, for the education of his children and for increasing the refinements of life. Even if it were true that scientific management curtailed the workman's opportunity to exercise real originality in his work, his intellectual life would still be the gainer from its introduction.

The workman's principal objection to scientific management is that he likes to do things his own way, to work as he pleases and when he pleases. Scientific management is objectionable to him because it compels him to change his habits, which is an uncomfortable process. If a workman were trained under scientific management from the beginning of his apprenticeship, and after several years were put to work in an ordinary shop, the change in habit would be just as disagreeable to him. He would object strenuously to being saddled with additional responsibilities while at the same time his pay was substantially reduced. The shipshod methods of his fellow workmen and the general inefficiency of the shop would grate on his nerves, and be ten times more disagreeable to him than the change in habits which scientific management usually introduces.

We must recognize that men are prone to complain and that anything new, especially if it involves a change in habit, will be the butt of the complaint. If they could not complain about scientific management, they would complain about the length of hours or the temper of the boss or the tools furnished for their work.

SCIENTIFIC MANAGEMENT INVOLVES A CHANGE OF HABIT

The fact that scientific management involves a change in habit which is disagreeable to many men is not a serious argument against it. People who become accustomed to living in disorderly and dirty surroundings find themselves uncomfortable when obliged to clean up and put things in order. Habits of labor which are inefficient are just as objectionable from the standpoint of the social welfare as habits of life which are unsanitary. Coming generations will look scornfully upon those who are inefficient, just as the present generation looks scornfully upon those who are dirty.

The change of habits involved in the adoption of scientific management is, from the practical standpoint, the strongest objection that there is. The minute you can show a workman that it is to his financial advantage to adopt the methods of scientific management, that minute all objections but this will disappear, but this one is ingrained in his temperament and nervous system, and cannot be reached by logic. Habit is one of the easiest things to form and one of the hardest things to eradicate, but even habits and prejudices must disappear at the demand of social welfare.

A great many misguided souls will urge against scientific management the same arguments which are urged against all other advances of civilization, namely that it impoverishes the imagination, takes the poetry out of life, puts men to work at machine-like tasks, etc. The same arguments are leveled against all improvements. The sanitary dwelling is less picturesque than the thatched cottage; the mowing machine is not so poetical as the scythe; the division of labor which enables ten little minds in combination to accomplish ten times the task that was formerly done by the ten master craftsmen is said to deaden men's souls and to limit their horizon. It is the eternal battle of common sense and the good of the community against selfish sentiment which regards only its own mental pleasures and takes no account of the good of the swarming many that are benefited by industrial advancement.

NO PROVISION FOR UNIONS OR "COLLECTIVE BARGAINING"

Another and very valid objection which workmen urge against scientific management is that it makes no provision for unions or "collective bargaining" as our friends the sociologists prefer to term it. It is undeniable that unions are necessary for the welfare of workmen and that without organized effort it would be difficult for them to maintain satisfactory wages and conditions of employment in the face of the tendency of capital to combine into trusts and associations. If scientific management is incompatible with labor unions, workmen cannot afford to accept it, because when scientific management has been adopted and unions have been destroyed, the whole of the benefits will be appropriated by capital, and labor will receive nothing for its increased efficiency.

Notwithstanding that many of the leading exponents of scientific management are opposed to labor unions, and believe that individual bargaining is one of the essentials of scientific management, this is not true. We can still have agreements in regard to minimum wages, hours of labor, conditions of employment, and many other things which affect the welfare of the workmen. The unions, however, must stop short of making any requirements in regard to methods of work or quantity of output or maximum wages paid or premiums given, because such things are not proper subjects of discussion between the unions and the employer, and because any effort on the part of the unions to interfere in such matters will harm workmen even more than employers.

I believe that the reasons that the advocates of scientific management feel their work to be incompatible with unionism is that many of the unions have in times past interfered in matters which were not properly their concern, and by doing so have harmed the cause of labor. Whether scientific management is largely adopted or not, unions will some day cease to interfere in these matters, because it is contrary to their own interests to do so. Since proper demands on the part of unions do not interfere with the operations of scientific management, and since those demands which would interfere with its operation are contrary to the interests of labor, I cannot see that there is anything incompatible in having scientific management in a union shop, and I believe that any effort to destroy unions when introducing scientific management can only serve to delay the date of its introduction.

Even the most serious objections to scientific management on the part of workmen, however, fall to the ground in the face of the fact that when scientific management is adopted workmen receive from thirty to sixty per cent in increase in wages. Not only will there be an immediate increase in wages as a result of scientific management, but with the extensive introduction of scientific management, there will be a substantial decrease in the prices of all those commodities in the manufacture of which it is generally applied. It is usually found that it is impossible to combat the self-interest of a community for a considerable period of time, and as soon as it becomes apparent that the working class, in common with all members of society, receives substantial benefit from scientific management, the objections to it will disappear and those things which at first were regarded as serious drawbacks will eventually be deemed to be mere trifles and in some cases be regarded as positive benefits.

OBJECTIONS OF THE PUBLIC TO SCIENTIFIC MANAGEMENT

From the standpoint of the general public, objection can be made to scientific management if it can be shown that it is inefficient, that it injures the health of the workmen, that it lowers the quality of the product, or that it brings about undesirable social or economic changes. The public does not, however, need to worry about the question of efficiency, because if scientific management is not efficient, it will not be used by manufacturers. Scientific management will for a long time be under very severe scrutiny by workmen themselves and it is unlikely that any harm will come to the physical welfare of the workmen unless in very exceptional cases.

Scientific management does not usually lower the quality of the product. In certain cases quality may suffer, but in most cases quality will improve as a result of scientific management.

Sometimes a decrease in the quality of the product is not a serious matter, while at other times it is. If it is, scientific management is prepared by proper inspection to insist on such quality as may be commercially desirable. Whenever the public is disposed to require a certain standard of quality, and is willing to pay for that quality, there need be no fear that the quality of output will suffer from the introduction of scientific management.

The principal objection to scientific management is that it will bring about very important social and economic changes with which our present laws are not capable of dealing. One of the effects of scientific management will undoubtedly be the destruction of the small manufacturer.[1] Scientific management achieves its greatest success in comparatively large plants. Those firms which adopt scientific management and are able to secure successful administrators, will crowd their competitors to the wall, eventually absorbing their business and becoming monopolies. Since our present laws are obviously inadequate to deal with such a situation, it follows that we must have a little scientific management in the law making department of our government if we are to avoid social and political evils from the growth of scientific management.

It may be pointed out in this connection however, that men of the " public-be-damned " class do not take kindly to scientific management. Men who are successsful in introducing scientific management are those who recognize their duties, and are prepared to act for the welfare of the community as well as of their workmen and themselves. And aside from this fact those monopolies which will be the outgrowth of scientific management will be less oppressive and objectionable than those which are the outgrowth of high finance, legislative favors, or the cornering of natural resources.

[1] Experience thus far does not bear out this statement. Plants in which scientific management has been successful vary in number of employees from about one hundred to about three thousand. In other words, they are small and medium-sized concerns. In view of the degree of centralization necessary under scientific management, it is rather to be expected that it would fit the smaller plant more efficiently than the very large establishment. — ED.

Another economic evil which may result from the adoption of scientific management is the mis-direction of effort which will mark the transitory period while conditions are becoming settled. The cause of this is that by the use of scientific management the output of an industry will be very greatly increased.[1] Sometimes the increase will be so great that the community cannot absorb the entire output at the cost of manufacture. The result will be that certain lines of work will be overdone and we will be some time in finding a rational and proper outlet for the extra productive capacity made possible by improved management.

SOCIAL AND ECONOMIC EFFECTS OF SCIENTIFIC MANAGEMENT

Upon surveying the social effects of scientific management, one is impressed with the idea that scientific management will improve social conditions very greatly and that there are only two economic evils prevalent at the present time that will not be materially diminished by the direct or indirect effect of scientific management. The first of these is the misdirected application of capital which results in potential overproduction in certain lines of industry. The second is the diversion of capital from industry for private pleasure. As an example of the first evil, I may cite the textile industry where capital is invested to such an extent that the mills are capable of filling all demands for textile goods when working at only a fraction of their capacity. Examples of the second evil are unnecessary since they will suggest themselves to most of my readers.

Scientific management must, in the long run, depend for its success upon the habit of mind of those who administer it. We think of the scientist as being a man who is, above all things, intelligently honest, who is without passion or prejudice; who is open-minded and determined to arrive at the truth. The scientific habit of mind is the only one compatible with the administration of scientific management. The man in authority must divorce himself from prejudice, from preconceived notions and snap judgments, and from everything which will turn him aside

[1] On the contrary, experience thus far has shown that the increase in output is sufficiently gradual to be easily provided for in advance. — ED.

from the truth. In adopting scientific management, he must recognize certain great principles; some of which are economic, some of which are psychological, some of which are ethical, and some of which are merely physical.

An industrial establishment is merely a part of a great economic system. Recognizing this, the employer will see that if the establishment does not minister to the needs of the community, it is useless. Not only must its product be valuable, but its work must be carried on in such a way as not to harm the community. Work which is carried on at the expense of a part of the community, in order to benefit the remainder, cannot be justified. By such work I mean work carried out under dangerous or unsanitary conditions, or where the wages paid are insufficient to maintain the community standard of living. It may be cheaper to carry on work in that manner, but the moral sense of the community will not in the long run permit of it, and scientific management recognizes the fact.

The interests of all men engaged in a given industry are identical. A certain school of thought is accustomed to regard the labor situation as a war, in which employer and employee are striving to obtain an advantage over each other, each striving to secure from the other the largest possible proportion of the total returns of the industry. Scientific management recognizes this to be an error, and knows that coöperation between employer and employee is essential. It recognizes not only that the employer must purchase the coöperation of the employee by high wages and fair treatment, but also that he must coöperate with the employee by assisting him in every way to become as efficient and valuable as possible. Each must coöperate with and assist the other, and must purchase by fair dealing and generous attitude the coöperation of the other.

The greater the productivity of a community, the more prosperous the community will be. High wages and restricted production are incompatible, and only by achieving the highest efficiency can the greatest prosperity be reached. There may be, however, overproduction in certain lines of work, because too much capital or too many men may be engaged in that line. This does not mean that too many men are employed or too much capital is available. It merely means that men are employed in the wrong industries and that capital is invested in the wrong lines. Consequently, the application of scientific management to all establishments engaged in one particular industry may result in throwing the industrial system out of balance by producing more of one kind of goods than is necessary.

CONCLUSION

Work well done under proper conditions is interesting and healthful when the worker is healthy and well nourished. Work under unsanitary conditions is unhealthful. A poorly nourished workman is always overtaxed by relatively small tasks. Unsatisfactory surroundings and slovenly work results in nervous strain which breaks down the workman's health. Men differ mentally and physically in innumerable ways, and each workman must be studied in order to discover the most useful place in which to put him. He must be put in that place where his abilities will be utilized to the utmost.

A careful study of a piece of work by a man of scientific habit of mind, having at his command the knowledge of a large number of expert workmen, will result in the development of methods of doing work which are far superior to the methods usually employed. Workmen naturally perform their tasks in improper ways as a result of habit. In order to have them perform the tasks in a proper way they must have supervisors to see that they form correct habits of work, and they must be encouraged by extra pay to continue in these habits.

The coöperation of workmen must be secured by persuading them that the employer has abandoned the attitude of war and that he is willing to divide the results of his improvements with the men whose coöperation makes these improvements possible.

Finally, the benefits of scientific management are so many and so varied that not only employers and workmen but the community generally will participate in them. It is therefore proper not to object to scientific management but rather to study the ways in which we can eliminate the evils which may possibly come from its use, and take advantage of the benefits just as we take advantage of the benefits of railroads, printing presses and steam power, in spite of the manifold evils which some men thought they foresaw as a result of their introduction.

UNSYSTEMATIZED, SYSTEMATIZED, AND SCIENTIFIC MANAGEMENT

By HENRY P. KENDALL

MANAGER OF THE PLIMPTON PRESS, NORWOOD, MASS.

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THE plan of this paper is similar to one written previous to the hearings before the Interstate Commerce Commission protesting against the general increase in freight rates. The purpose of that paper was to make clear what was meant by Scientific Management, a term then unfamiliar. To present the same line of thought again receives its justification by the first words in the announcement of this conference, which states: "Notwithstanding the fact that much has been written concerning Scientific Management in newspapers and magazines, there is no definite conception in the minds of manufacturers and business men of its nature."

That this type is not well known even now is scarcely to be wondered at. Until recently little had been written for the public press and but few manufacturers were working under it, and the small group of men who were associates of Mr. Taylor, or kindred spirits, were too engrossed in their own tasks to do much talking or writing. It is my object, then, to illumine Scientific Management by describing it in terms of business with which we are all familiar, and by comparing some of its essential features with those of more familiar types of management.

Any manufacturing or mercantile business made up of different processes more or less interdependent must, to secure the best results, be so organized that the separate processes and the unit members within these will be brought into systematic connection and operation as efficient parts of the whole. To bring about and maintain this is the function of the management. To do it to the highest known degree is possible only by what we choose to call the science of management.

All types of management seem to fall readily under three heads which, for want of a more explicit terminology, we will call:

I. Unsystematized Management.
II. Systematized Management.
III. Scientific Management.

Of course no classification of this kind is exact. Some departments of an unsystematized plant may equal those in a systematized, and likewise those in the second class may approach the third in efficiency in places; but on the whole this seems a natural division. The functions of the three types of management which will be compared are:

A. Accounting.
B. Purchasing.
C. Storage of Materials.
D. Execution of the Work.
E. Efficiency of the Workers.

I. Unsystematized Management

This classification is not made on a basis of the earnings of this group, nor does it mean that they are not meeting their own competition successfully or making money. Such a condition depends on the margin which exists between their costs and selling prices. It does classify them on a basis of efficiency, and means that their costs are not so low as they would be were their form of management the systematized or scientific type. In the opinion of the writer fully 70 per cent in number of the plants in this country would belong in this class, and they are easily recognized. I do not mean that 70 per cent of the workmen in the country are working under unsystematized management, but I think that 70 per cent of the concerns in number would come under this class. We will look at the first function, namely:

A. *Accounting*. The accounting in a business includes not only the ordinary bookkeeping, but the entire clerical system which has to do with orders, records and costs. Accounting is the only means by which the management is informed from time to time of the condition of the business, the progress it is making, its weak and strong points, its selling values and costs, and the efficiency of all its departments. How thorough, lucid and complete the information is as shown by the books indicates to some extent the efficiency of the management and its grasp on the affairs of the company. In the *unsystematized* plant the accounting generally consists of a statement prepared after the annual or semi-annual stock-taking, which shows (1) Profit and Loss; (2) Assets and Liabilities. It may possibly show profit and loss by departments or by products, but this last depends on a correct method of ascertaining costs which the *unsystematized* plant seldom has. Such statements are merely a record of an historical fact in most cases. If the statement is bad it is too late to remedy the troubles of the previous year because it shows merely the result of that year. Frequently, due to imperfect methods of stock-taking, appraising and compiling, the yearly statement may be delayed; then the history it tells is ancient.

One example from my own observation — by no means unusual — will illustrate: A large concern ended its fiscal year on January 31 and did not know the result of its year's business until July 17 following, and then in the simple form of profit and loss, assets and liabilities. This information came nearly six months after the close of the business year and was then from six to eighteen months old, too late to do anything to stop the leaks of that year. This was a dangerous case, but a common one.

Any firm of accountants can testify that it is no unusual thing to audit the books of a concern which thinks it is prosperous, and to show that concern that it is insolvent. Within twelve months the writer has had experience with a business in which an audit was made of the books because the proprietor thought his bookkeeper had been dishonest. The audit showed that the bookkeeper had been honest but that the concern was insolvent, and shortly after it paid its creditors thirty cents on the dollar.

A lack of proper cost accounting in the *unsystematized* plant is the cause of losses and of many failures. A notorious example of this appears in the printing industry. In Chicago one large department store makes the boast that it secures its printing below cost. Its method is to send for estimates on printed forms to a large number of printers for every job of printing it has to give out, and then to give it to the lowest bidder on the assumption that some one will have figured below cost. It is reported that at the close of one fiscal year there were no less than fifteen failures of printers in the city of Boston, and it would not be strange if this proportion held throughout the country in this particular industry.

So much importance is placed upon cost of printing at the present time, that one national organization of employing printers has no less than eight men employed installing uniform cost systems in printing offices of its members throughout the country. Too little importance is placed upon accounting in the *unsystematized* plant, and as increasing competition in various industries is continually lowering the margin of profit, the accounting must become relatively more and more important to this class of business.

B. *Purchasing*. The purchasing of materials, stock and miscellaneous supplies under this type of management may be done by one man or by a purchasing department; but more likely this duty is not very well defined and the purchasing is done by a number of persons, especially those needing the material. Little study is put on the standardization of materials, and different kinds of stock for the same use are often bought. This tends to remnants on some kinds, overstock and understock on others. The buying is seldom done on exact specifications, is not always even by written order, nor is there a predetermined maximum and minimum established of each article that should be carried in stock. The head of the business or the buyer may be an exceedingly shrewd trader and may buy very close at times; but he will not always buy the materials best suited to the work, often overbuys or underbuys for lack of definite information, and is frequently tempted by bargain lots that seem cheap but may cost more to use in the shop.

The lack of well-organized purchasing results in work progressing to a certain extent through the shop until it is stopped and occupies space waiting for some material which has been overlooked, or which is not suited for the purpose. A fairly successful publishing house in one of our large cities does its buying by the *unsystematized* fashion. Last year in making up its statement of profit and loss, the inventory of paper amounted to $20,000. Three-fourths of this paper exists as overruns, or odds and ends of lots which are stored in various printing offices and cannot be used on an average-sized job. They are so scattered they cannot be combined and the make, color, finish and size are different in nearly all the lots. When this house realizes what this stock is, it will be forced to write off nearly $15,000 from its books on what it now considers good assets. Had the buyer in that publishing house standardized his paper so that whatever remained from one lot could readily be used on the next, had concentrated paper of certain kinds in one printing office, and had accurate records of his available supply, this amount of money represented in stock could be appreciably less and would equal the original cost of the paper. This sort of buying is common among *unsystematized* concerns.

C. *Storage of Materials.* Many manufacturers are willing to devote unlimited space for workrooms, not realizing that the room for the proper storage of materials is just as important and just as profitable as that used for manufacture. In the *unsystematized* plant there may be a general storeroom, but seldom are all the stores to be found in it, and generally they are piled around almost anywhere and in any way that happened to be convenient when received. The order in which such stores are kept usually depends upon the initiative of the men directly in charge, and seldom can one person assume or carry out this responsibility.

The storage of materials and purchasing are very closely related to each other. Loss of time hunting for material is the same whether the material is lost in the storeroom or has not been purchased, and a lack of system in one department will undo attempts at system in the others. The effect of badly organized stores is: (1) Loss of time; work which should go through the manufacturing departments rapidly is held up at different places waiting for materials of the proper kind or amount, and this is a direct loss. (2) Loss of space; more space is required to hold stores in an *unsystematized* way, and for lack of standardization more stores will be kept on hand than are required. Space is also lost in the workroom because work in process does not pass promptly through the workrooms if delayed for material. (3) Loss of capital, because more money is tied up in stores which are not systematized and properly regulated, and more money is tied up in the jobs which represent labor and material sidetracked throughout the plant. A lack of proper records of stores is almost always to be found in the *unsystematized* plant, and the management seldom sees the need for the so-called extra work necessary to conduct that department properly.

D. *Execution of Work.* Orders in the *unsystematized* shop are recorded in a simple manner, sometimes even received and transmitted verbally by the salesman. These are described in part verbally to the superintendent, who may further enlighten the foreman on any of the details of such orders. It is assumed that the superintendent knows his business, that the foremen know theirs, and a workman is expected to sense what is wanted and to ask questions when he is not sure. In this way an attempt is made to fill in the exact and accurate information which the selling end has either not secured or has not transmitted in writing.

The "single foremanship" plan prevails where one foreman handles as many men as he can. The number of men and the amount of work he can look out for is limited by the amount of detail which he can carry in his head and by his physical and nervous endurance. He gives work to each workman when the latter has finished his last job, and depends largely on the worker's knowledge of what to do and how to do it. As questions arise in the progress of the work, or where the written order is incomplete, the workman goes to the foreman who in turn goes to the office for instructions. Meanwhile progress on the work stops.

The workman goes for and selects his tools and appliances, and does his work in the way in which he is accustomed to do that particular kind of work. A difference in method of doing the same kind of work by different workmen and in different shops is often quite marked. A detailed schedule of the average workman's day in the *unsystematized* shop, where such day's work is varied, will show a surprisingly small proportion of effective time.

Piece work is often used, but is bound to be unequal. The rates, determined by no exact method, are often subject to change, and the output of such piece work is frequently limited by the unions. This lack of planning the work at the start, of complete instructions, of coördinating the departments and routing work throughout each operation, results in a congestion of unfinished work at many points. This slows down the output, occupies space and ties up capital. The frequency of mistakes in rush times and of shortages that must afterwards be made up, are not always called to the attention of the management. It is exceedingly difficult also in this type of plant to secure a high quality of work and to maintain it uniformly. Then, too, the costs fluctuate a good deal.

E. *Efficiency of Workers.* The efficiency, as a whole, is low and especially so in dull times. It is uneven and varies according to the executive ability of different foremen. The output of a man or machine is largely determined by the opinion of the foreman and not by any exact standard. Piece work is not always fair, and may be too high or too low. There is no special incentive for a foreman to coöperate with the workman. Therefore, while the majority of the men may be doing what they consider a fair day's work, and some few may be working efficiently, the efficiency of the whole is low.

One example will illustrate a well-known loss in efficiency. A workman in the hat trade performed one process in making a hat by piece work, and earned not over $15 a week. He was well adapted to that kind of work and could easily have earned $25 a week at that rate and would have been happier doing his best, especially as he needed the money. He was limited to $15 a week by the union. It cost that firm more by this method, because the floor space occupied by this part of the work could have turned out 60 per cent more hats if the men had been rightly selected for that kind of work and had been permitted to do their best. It also cost more because overhead charges were 60 per cent more per hat than was necessary for that operation. More than that, a workman who is well fitted for a task is not happy when he is not doing his best and earning all of which he is capable. There is an economic loss to each, and the result is bad. Even greater inefficiency than this may occur with day workers.

II. Systematized Management

This term as used here applies to the well-organized and managed plants which make no claim to Scientific Management as such. In these plants the managers are methodical and systematic, have studied and systematized each department carefully and aimed to secure the best that has been done in the line of systematizing up to the present time. As stated before, in some departments of many such plants the efficiency is exceedingly good.

A. *Accounting*. In this form of management the accounting is well done. The books will show the condition of the business quarterly or monthly, and in considerable detail. This will include the comparative feature; that is, for example, last year's costs to date with this year's costs for the same period, for a given department or product; will show costs of materials and labor, and the proportion of overhead charges that make up the cost of a single job or a given product. Such results may even be charted and shown in graphic form to the management each month. Other records will come up weekly or even daily. As accounting is the means by which is ascertained the exact condition of the business at a given time, the *systematized* management recognizes the importance of this information. Much of this accounting, however, is done with the ultimate end of securing correct costs, and these cost data are relied upon almost wholly, (1) to establish the selling price, and (2) to point out excessive costs and indicate perhaps where they may be reduced. Many believe that when their accounting is well done they have a systematized and efficient plant, but this really covers one phase only of the management.

Frequently, too, the clerical work in the different departments is not a part of the general accounting, and is not controlled by the ledger accounts. In other words, the same general system of accounting does not permeate the whole plant and help to support itself.

B. *Purchasing.* Materials and supplies are purchased through one man or department, a maximum and minimum generally established, and a decided effort made to purchase the materials best suited to the workrooms. Some analytic methods are used in determining the proper materials, and standardizing is done on the more important kinds. This purchasing department aims to have a stock of everything required, but buys largely what it is asked to. It does not always make purchases on complete specifications, and a lack of complete standardization increases the detail of that department. So far as the clerical system is developed, however, it is generally quite good.

You will recall the words of a well-known railroad president some time ago who stated, before the Interstate Commerce hearings, that the railroads had reached their ultimate end of efficiency. It is interesting in the light of this statement to note an example of efficiency in purchasing by one system of railroads, which has been acknowledged to me by railroad officials as leading in this particular department. This is the purchasing as done by Mr. Thorne, who buys over $40,000,000 worth of materials annually for the Union Pacific and Southern Pacific railroad systems. One characteristic of Mr. Harriman when he took over a railroad was that he would go to any expense in order to standardize every bit of material used. Mr. Thorne is the man who carried this out. In a letter the other day he told me that in the standardization of printed forms alone he had saved over 30 per cent in the purchase of that particular commodity. In standardizing these forms he reduced them in number, specifying certain standard sizes of paper, type, and other conditions to be followed, and I have no doubt that in his other purchases his methods have secured a great saving over those of competing roads.

C. *Storage of Materials.* A marked contrast to the storage methods of the *unsystematized* plant will be seen at once. Here is an adequate room in charge of a storekeeper who issues stores only on requisitions, and is expected to keep his place neat and orderly and deliver his stores on call. A perpetual list is kept in the office and balanced with the stores, and the balance is proved by an actual count of the stores once a year or oftener. Stores are partially classified and standardized to some extent. It is only the most-used stores that are assigned to orders before actually called for. The physical handling of the stores, moving them in and out of the storeroom, is done by the assistants of the storekeeper and the efficiency of this work and the orderliness of the department depend wholly upon the kind of man in charge. The central office can exercise very little real control in this department.

Not all *systematized* plants control work from a central planning station by writing the operations for each process before the work is started; therefore materials are not exactly predetermined and work is still likely to be started before it is discovered that some material is lacking. Neither are the quantities always kept up automatically through the purchasing department by a predetermined maximum and minimum of each kind. Also, it is general practice to have storage space for different departments, some of which are not under control of the office; for instance the miscellaneous supplies used for the power department for repairs, piping and plumbing, electrical maintenance, etc., may be scattered about with little idea of order, while the actual materials for use in manufacture may be in good order.

D. *Execution of Work.* A complete set of order-cards for recording and transmitting orders is in use. The worker receives a written order for the work he is to do. This seldom takes the form of an instruction card giving him complete information for every move and every tool. It is apt to say *what* the work is, assuming that he will do it in a satisfactory manner. Workers almost always record their time for each job on a card, which registers the labor cost accurately. They do not always register the time lost in securing tools, materials and further instructions. The planning of a job, except in plants where the work is very largely repetition, is likely to be done as the work proceeds. Piece work is used wherever possible, and is considered the most economical way of performing a given operation. It is the aim of most *systematized* plants to secure as much piece work as possible. This may be unfair for different kinds of work to both employees and employer.

Under *systematized* management the system keeps things running smoothly, avoids most of the mistakes due to the lax methods of the first kind of management and turns out a good product. But a lack of centralized planning and centralized control of the workers causes loss of efficiency.

E. *Efficiency of the Worker*. The emphasis of *systematized* management is laid on costs, freedom from errors and bad work, and the greatest output per man and per machine that can be secured. The standard for this output is generally established by the opinions or experience of the bosses, who have neither the time nor the training to ascertain it by exact methods. Great emphasis is put upon the installation of new and modern machinery, but there is not very much analytical work done by the management to ascertain whether the worker is working in the very best possible way, or whether he is adapted to the particular job he is given. The person who has charge of the employment considers that there are four classes of people, — men, women, boys and girls. If the foreman wants a girl, that is sufficient information for the one in charge of the employment, and a girl is hired and assigned. Little or no thought is given to the question whether that particular girl is the right one for the task.

For instance, in bookbinding there are different kinds of work. Laying gold leaf calls for a girl with small fingers and a delicate touch. Strength is not required. Another operation calls for a large, strong girl, who can easily handle bundles of work weighing seven or eight pounds. In proofreading the time reaction of seeing a word and grasping its meaning is a very important feature. Other girls doing inspection must have the ability to will have five pay-rolls where others have four, and the number of working days varies by quite a per cent because there may be five Sundays or five Saturday half-days.

In substance, the general accounts of the company are shown in more complete form every four-week period than is shown by the yearly accounting in the *systematized* class. The ledger accounts have absolute control over the stores department, over the quantity and values of stores, work and materials in process, and manufactured goods; and as every department and function of the manufacturing coördinates with every other, the accounting becomes a part of the very bone and fiber of the manufacturing.

One radical difference in point of view is that the ascertaining of costs does not have a special system installed for just that purpose, and the ascertaining of costs is not the end sought. Under Scientific Management costs come as a by-product of the means used for increasing efficiency. For instance, a ticket made up in the central planning department, when combined with the instruction card, serves to plan the work in advance; then it is used to control the order of work by being placed on a bulletin board; then it gives the workman his particular piece of work to do with the instructions how to do it.[1] On this ticket is stamped the time at which the work is begun and when it ends. This same ticket then serves to check off the progress of the work on the route-sheet. Then it goes to the accounting department from which the man's pay is made up. It is then redistributed and furnishes the labor cost of the particular operation on the cost-sheet of the job. From cost-sheets similar to this are summarized not only the cost on all jobs, but department expenses and charges which appear in each four-week period statement.

In other words, the mechanism used under *systematized* management for ascertaining costs performs little other work; under Scientific Management it has performed its part in producing work, and from it, as a by-product, so to speak, come the costs.

[1] The card referred to is the job card, for which see page 427 in this volume. — Ed.

The ascertaining of costs by this method is done with but little more expense than is necessary for handling the regular work of operation. Too much emphasis cannot be placed on the value of the comparative feature in accounting. Comparisons are a great spur to increased efficiency, and this fact is recognized as well in the *systematized* management. For example: a certain group of department stores, each doing a business in a different city and non-competitive, have found such good results from uniform accounting methods and the information that comes from comparison, that they jointly employ an accountant who collects the monthly reports in detail from those stores so as to make a comparison by items, and then prints these data for the use of the management of each store.

For instance, one manager finds that Department A in his store did $50,000 worth of business the preceding month, had $35,000 worth of stock on hand, and is shown in detail what the labor and other expense items of that department were. He sees that another store did $55,000 worth of business in Department A and had a stock of but $20,000. He immediately summons his buyer and informs him of the result of this comparison, and asks why he cannot do as well as the buyer in the other store and release $15,000 of capital now tied up in stock. The knowledge of what can be done and is done by the other store is often sufficient stimulus in itself to cause to be accomplished what otherwise would not be considered possible.

The expense and frequently the shutdowns for the purpose of the annual stock-taking are eliminated under Scientific Management, because the accounting absolutely controls the movement of materials in and out of the stores department, so its records show at all times the amount in stores and this value can be ascertained when desired. The work of proving the items of stores is done continuously, and the days, which often become weeks and months, that elapse before even large and well-organized concerns get the results of their stock-taking become a thing of the past. One large concern which is a customer in a business in which I am interested finished its year of stock-taking January 1, and it was early in August of this year before it got the results and knew how much stock it had on hand January 1. The same will apply to the amount of materials and labor in process, which the *systematized* management finds even a harder problem to handle, and also to the value of manufactured goods.

B. *Purchasing*. Scientific Management is not satisfied merely to have plenty of materials on hand when wanted, to roughly standardize the principal items of stock used and to buy at the market rate, but demands that all materials be carefully studied with reference to —

First. The greatest adaptability to the work.

Second. Quality and uniformity.

Third. Price.

Fourth. Determination of the proper maximum and minimum that shall be carried, so that the stores department may automatically govern materials and supplies which should always be on hand.

When this has been done, care is taken to make all purchases on detailed specifications. The importance of using materials best suited to the work and which are uniform in quality and by standardization reduced to the smallest variety, is not sufficiently appreciated by the buyer in even the *systematized* plant.

For example, a manufacturer of razors using a thin blade could not secure a steel which would always act alike and produce a uniform result with uniform treatment. He employed a steel expert of reputation to assist him. This expert purchased the best razors that different barbers had, analyzed them chemically and microscopically and, as every man who uses a razor might guess, found very great variation even in the same makes. In fact, he satisfied himself that no razor manufacturer, however well-systematized his plant was, had ever scientifically determined the best steel, or had purchased it on a formula that would standardize this material. As a result, all these years the buying of a razor had been a lottery.

After many tests this expert secured from various steel manufacturers samples of steel on their formulae and his own, and he finally developed a formula that would give the best razor steel known and maintain it uniform. As a result of this method of buying this manufacturer stood alone among the razor producers of the country in ability to produce razor blades of standard quality. If all his methods are as scientific as this, it is doubtful whether his competitors will ever overtake the lead he has secured. This is not an extreme example by any means.

Another illustration of the standardizing of materials. In studying the supplies of a business it was found that there were twelve kinds of wrapping paper regularly used and an investment of $2,500 was needed to carry a sufficient amount. This was standardized and now the twelve kinds of paper have been reduced to four, with a saving of $1,000 in the stock, 60 per cent in the storage space occupied, and the available worth of this paper for the demands that may be made on it is 20 per cent more than what it was formerly. This illustrates the saving made on but one class of material used in a factory where standardization is being worked out.

Such methods of purchasing compel the purchasing department to be intimately associated with the working of the materials through manufacture, and result in the following: —

First. Uniform material best adapted to the work saves labor and delay in workrooms.

Second. Minimum of kinds and sizes necessary to be carried.

Third. Storage space saved.

Fourth. Lower costs through buying in larger lots.

C. *Storage of Materials.* The physical aspects of a storeroom under Scientific Management do not differ greatly from those in the *systematized.* A proper means of holding or piling the stores, laid out in an orderly fashion, is provided. To avoid confusion in a varied terminology, mnemonic symbols are used to designate the different kinds of stores. The maximum and minimum mentioned above are determined for each kind, and kept on the ledger sheets in the central planning room. The bookkeeping for the stores is not carried on in the storeroom, the storeroom force simply acting on orders. The location of the materials is also indicated on the ledger sheets, or, as they are known, the balance of stores sheets.[1]

The storeroom in the *systematized* plant is not likely to carry all the materials and supplies used in the entire plant. The engine-room, plumbing and construction supplies may be carried in places provided for them, but not controlled as other materials are. Stationery and office forms and supplies may be carried somewhere else under a different system. Even in well-systematized plants such items as are not considered a part of the general stores system cause more or less trouble by being used up unexpectedly.

Under Scientific Management it is not sufficient, when materials are required, to send a requisition to the stores department, but all orders or work which require material have the items looked up and assigned to the specific orders by the balance of stores clerks, and this material when assigned to a given order is not available for another order which may follow. This is done before the materials are required for use, and this method serves as advance warning to the stores clerks if an unexpected demand for a particular material is likely to occur. Quick action is then possible in purchasing more.

The work of moving materials into the stores department and moving them from the stores department to the particular place where they are to be used becomes a function of the planning of the work, and of the routing of the work, and the workman who is to use them should not be delayed or have to give a thought to the materials which he needs for his next job. They are moved in the right condition for his use to the point where he can use them to the best advantage. The *time* which the workman spends looking for or waiting for his materials can be better spent in effective work. The proper working of the stores department in many industries, and especially in mercantile establishments, is a very important one.

D. *Execution of Work.* The theory of the proper execution of work is that it should be planned completely before a single

[1] Cf. F. W. Sterling's "The Successful Operation of a System of Scientific Management," p. 296.—Ed.

move is made, — that a route-sheet which will show the names and order of all the operations which are to be performed should be made out and that instruction cards should be clearly written for each operation. Requisitions on the stores department showing the kind and quality of the materials and where they should be moved, and lists of proper tools for doing the work in the best way should be made up for each operation, and then by time study the very best method and apparatus for performing each operation is determined in advance, and becomes a part of the instruction.

By this means the order and assignment of all work, or routing as it is called, should be conducted by the central planning or routing department. This brings the control of all operations in the plant, the progress and order of the work, back to the central point. Information which even in the *systematized* plant is supposed to be furnished by the knowledge of the workman or the gang-boss or foreman, is brought back to the planning room and becomes a part of the instruction card.

In many *unsystematized* plants no attempt is made to change the method by which the workman performs his operations. Plenty of time and money may be spent on special machinery, but when that is installed very little time is spent in a close analytical study of the time elements and motions involved in operating, in order to make it possible for the workman to work in the easiest and best way and to furnish a fair basis of remuneration.

When the analytical study has been made, the probable time of operation determined, and a sufficient incentive has been added in the shape of a bonus for performing the work in the given time and in the way specified, then work can be much more accurately controlled from the central planning room because it is likely to be done in approximately the time determined and without lagging.

By *functional foremanship,*[1] which has been described by previous speakers, the management brings to bear on each phase of

[1] Cf. H. K. Hathaway's "The Planning Department, Its Organization and Function," p. 366, and "The Foreman's Place in Scientific Management," p. 395. — ED.

the work a man particularly fitted by selection, training and experience to assist in performing that part of the work. His function is to assist the worker and coöperate with him to enable him to increase his earning capacity by eliminating trouble or delays or wrong methods. Even in the well-managed *systematized* plant the manager will tell you that the weak point in his business is the inability to secure good foremen, or good superintendents. He demands: —

First. That a foreman shall know all about the work which is done in his department.

Second. That he be a good disciplinarian.

Third. That he have the ability to crowd work through and get it out quickly.

Fourth. That he be cautious and accurate.

Fifth. That he be able to keep account of innumerable details.

To find all these qualities combined successfully in one man is exceedingly difficult, to train such men is also difficult, and to secure them by natural selection and " survival of the fittest " takes too long; but to train men for functional foremanship by selecting the best man fitted to do the particular function and then training him in that, is simply one kind of division of labor which has marked the progress of civilization.

The execution of work which is largely repetition, where the individual processes are simple, reaches a very high efficiency in many *systematized* plants. The difficulties in securing efficiency increase as the work becomes more varied and with less proportion of it repeat-work, and in proportion as these difficulties increase ordinary systems fail to produce results in more intricate work. This can be attained, however, by the central planning room from the analysis and time study which is put into all operations of work and reduced to instruction cards.

E. *Efficiency of the Worker.* On many simple operations in manufacturing, piece work has always been considered the most efficient method of securing output and low costs, and it is true that where the remuneration is a just one and when the employee is supplied with proper materials and works to the best advantage, this method of performing work approaches very close to that of Scientific Management; but such conditions of piece work are the ideal rather than the usual. As stated above and emphasized by previous speakers, piece work with prices based on the snap judgment of a foreman or by an imperfect test of a single worker, is not the correct method to secure the greatest efficiency. Besides this, there are many kinds of work which are not adapted to piece work. Under Scientific Management the efficiency of the worker and machine depends on five other conditions, after assuming that the parts of the management which have to do with purchasing, storage of materials, etc., are well performed. These conditions are: —

First. Analysis and synthesis of the elements of operation.

Second. Scientific selection of the worker.

Third. Training of the worker.

Fourth. Proper tools and equipment.

Fifth. Proper incentive.

First. The first condition on which the efficiency of the worker depends is that *the management shall analyze carefully and thoroughly every operation into its ultimate elements;* shall then reconstruct those elements in their proper sequence, eliminating those which are unnecessary or those which are bad, and reducing the form to a written instruction card for him to follow; the time elements having been determined and becoming a part of the instruction card. It is interesting to see what develops when one really begins to study a seemingly simple operation. The motion study alone of bricklaying makes possible the elimination of sixteen unnecessary motions. The change in location of a machine which was operated by a girl who sat with her back to an aisle where heavy trucking was done caused an increase of 25 per cent in her work. Every time she heard a truck approaching she involuntarily shuddered, probably wondering if the truck would strike her. Removing this operator to a quiet corner caused the increase.

One factory doing light manufacturing has lately put some time into studying what have always been considered simple operations. In certain places a differently shaped receptacle was made for the articles on which work was being done, bringing the pieces within six inches of the left hand, whereas for years before the worker had had to reach for these and occasionally stop work to bring the articles farthest away within reach with a sort of hoe. Other operations in this plant have been simplified by changing the position of some workers so that the porter who supplies materials can do so without interrupting and causing a stop in the work several times a day. A study of extra steps and little delays by an intelligent observer is a necessary work before the greatest efficiency can be secured. When all these analyses have been reduced to writing, a study of the type best fitted to do this work is made.

Second. Scientific Selection of the Worker. The type of worker who physically and mentally is best fitted to do a kind of work must be selected after a careful analysis of that class of operations made with reference to the physiological and mental differences in human beings. The difference in output and quality of work has been found to vary as much as 40 per cent or 50 per cent in a group of men or women engaged on the same kind of work. As they were of apparently equal intelligence and education, this could be explained only by the physiological and mental differences. As a result of time study and motion study of various groups of operations in one large manufacturing plant, it has been found that there are so many workers performing a kind of work to which they are not suited, but who might excel in another kind of work, that the management has laid plans to establish classes to instruct workers to do another kind of work better adapted to their capacities.

Of two different departments, A and B, for instance — A containing thirty girls and B twenty — it has been found that over 20 per cent in A are unfitted for that kind of work, but would be fitted for work in B, and *vice versa*. A scientific selection of the workers is possible only from the analysis of operations. The effectiveness of this will be greater when the principles of the psychology of working and kinds of work are better understood by industrial managers.

The psychology of advertising has lately been coming to the front. The psychology of industrial workers is still a great field for research. The vocational schools will not perform their true function properly until they come to a better knowledge psychologically of the mental and physical requirements for different kinds of work, and are able by tests to determine in which their pupils are likely to be successes or failures.

Scientific selection of the *workmen* is but a part; the scientific selection of *foremen*, of *superintendents and managers is just as important*. How frequently one sees a man struggling with the details of an office or with the wear and tear of executive work, on the verge of nervous prostration, when that man is wholly unfitted for that kind of work and his attempts successfully to perform it result in his undoing. If managers themselves knew how to judge a man's fitness for his work and were more observing, there would be many less breakdowns and physical wrecks than there are now.

Third. Training of the Worker. Having first carried out the study of the operation which has pointed the way to the proper selection of the worker, it becomes the duty of the management to train the worker to do the work in the way which the result of the analysis has shown to be the best way. This will be accomplished by a functional foreman whose duty it is to train the workmen and help them on each job to get started right. If they fail to do the task in the time fixed it is the duty of the functional foreman to find out why they have failed, and to help them do the work as it should have been done. This is a wide departure from the old school, which assumes that the journeyman has sufficient knowledge to do his own work in the most efficient manner. In the training of workmen it is interesting to see how they develop through an aroused interest and coöperation of those over them.

Fourth. Proper Tools and Equipment. The fourth condition is that the worker be supplied with the best tools and just the ones needed for the particular operation, and supplied when needed; that he be given the best machine, maintained in first class condition, so that machine, belt and tool failures will be reduced to the minimum. To maintain the machinery, etc., in this condition is a duty of the management, and Scientific Management provides the means with which to do this.

Fifth. Proper Incentive. Sufficient incentive should be given the worker to perform the operation or the task that has been set in the given time. To make this possible for the worker, functional foremanship is necessary and the principal object of such functional foreman is to assist the worker and eliminate trouble or delay. The functional foreman trained to his specialty will do this more effectively than the old-fashioned all-around foreman. Examples have been given by previous speakers of relative increase in efficiency of the worker as a result of Scientific Management. Of course such relative increases in output cannot be considered universal. Certain machines are not mechanically able to run at double or triple their former speeds, but Scientific Management tends to lessen the numberless little delays which the condition of the machine, of the material to be worked upon, or the instructions to the worker may have been responsible for.

It must be to the financial interest of the worker to be industrious, and it has been shown to be for the interest of the management to do everything to make possible and profitable this increased industry of the worker, thereby gaining a more uniform output, and an output per man or machine which is maintained more uniformly in dull or busy times.

There is another feature which is of interest; that is, if the worker engaged on the task and bonus does not receive his materials promptly and on time, if his machine is not in the condition it should be, or there are other avoidable delays, the worker has sufficient interest in the probable loss of his bonus to make a serious kick, and it is the duty of the gang-boss to immediately right this trouble. Therefore, the workman and the boss are together demanding of the management that as nearly as possible perfect working conditions be maintained.

CONCLUSION. The central planning and control of work which is such a vital part in Scientific Management is not developed to the same degree in the *systematized*. In *systematized* plants where complete planning is attempted, however, the instructions and orders particularize *what* is to be done rather than *how* it is to be done.

In the *systematized* plant the system in one department has been planned especially for that department, and is not a part of the system framework which pervades the whole, as in Scientific Management, and it is a constant fight to maintain such independent systems and especially to change and modify them with changed conditions or the increased growth of the business.

In closing let us see the effects of this type of management in general on the plant, the product, the worker and the management.

Plant. Scientific Management furnishes the machinery for maintaining the plant in better condition by centralizing the control, by the use of such devices as the standing order file in which are collected and reduced to writing and properly indexed the practices and rules of the company. From it, by listing and making a certain program of things to be done, — the departments, machinery, shafting, drains, gutters, etc., to be inspected, — this program can be handled month after month by routine in a manner which the management has carefully predetermined. To attend to the maintenance of a plant in this way is working to prevent delay and expense rather than cure it afterwards. For instance, eliminating delays due to belt failures, shaft-boxes which have been overlooked and run dry, and indefinite inspection of premises, pipe lines, traps, etc., tends to save expense by preventing trouble.

Product. The product of such a plant should be more uniformly even, and there should be fewer mistakes and less inferior work. Once a standard is set for each operation, that standard can be maintained. It costs little more to maintain a high standard under these conditions than a low one under old conditions.

The Worker. The condition of a worker's mind has a very large effect on his physical being. There is a psychological effect on a worker in having the work divided into definite tasks, each one having its goal in sight and sustaining effort to that time. The piece workers in one plant in which I am interested were interviewed by a woman journalist at the time so much publicity was given to Scientific Management by the hearings before the Interstate Commerce Commission, and she asked them how they liked the task and bonus. They said they did n't know why it was, but they liked it; they were earning more. But that was not all: the piece work flowing to them in an unending stream had been discouraging; there was something they could not understand, but when it was broken up into definite lots they liked it much better. You can discourage any man by setting him to work with a pick and shovel and telling him to shovel away a hill. He knows he can never get it done, but if you say; "Here, you shovel so many tip-carts full in a day, or in a given time, and you will have a certain percentage of increase of pay for that time," you have changed the point of view, and that man every time he finishes a tip-cart full has accomplished a definite task. His effort is sustained for that time, and he is going to be able to sustain that effort in the future. That is one reason why profit sharing among the working classes is almost an absolute failure so far as increased efficiency is concerned; the time of sustained effort for a year or six months is too long. Neither can a worker do his best work who is nagged by a foreman, who has been given insufficient instructions and is fearful lest he is doing his work wrong, and who, having made a mistake, is jumped on, oftentimes perhaps unjustly. He is not in a frame of mind to do his best work if he wishes to.

In one factory there was great difficulty in keeping the women workers in a certain department. They were either unwilling to continue to work or frequently gave out, and it was a puzzle for some time to find out what the trouble was. When the analysis and time study were put into this department, it was found that part of the trouble was due to the fact that they were not earning so much as workers in adjacent departments, that they were nagged by the foreman who did not understand how to handle help, and that they were working at a disadvantage in the arrangement of their work places. The first step was to fit up their places so they could work to the best advantage. A time study then showed that by working according to instructions they could easily do 50 per cent more work. To insure the work being well done, one of the best girls was selected as an inspector and given charge of their work, the foreman having nothing to do with them. A few of the girls were tried on the extra work, — working under the constant instruction of the time study man and being paid an additional amount.

All the girls who were physically fitted for this kind of work tried the extra amount, which they did easily. The result of the extra pay, freedom from the nagging of the foreman, and easier working conditions, immediately stopped the difficulty in keeping workers in this department. One or two of these workers, according to the report of the factory nurse, have gained weight since this change was made.

After this had been in effect for a while, the constant request of one girl that she be allowed to undertake one-third more work, or double the original amount, was granted with the approval of the factory nurse, who watched her closely. This was a task not set by time study, but one which the girl herself thought she could undertake. She found, however, that it was too much and gave it up voluntarily, but she is still doing 50 per cent more work than she was originally. She is a girl well fitted for the kind of work and for her a larger task could be given, but tasks are set with the idea of the average worker who is first selected for the particular kind of work. It must be considered that the effect of task and bonus work under the proper conditions tends to greater industry, better discipline, a happier disposition and greater interest in work on the part of the workers. Greater regularity, greater accuracy and neatness must and do have an influence on health and character.

Management. It is probable that the point of view of heads of departments and those responsible for the management becomes quite as much changed as that of the workers. When mistakes are made the responsibility is fixed and the management cannot dodge the fact. A manager also realizes as never before the value that must be placed on analysis. As Mr. Taylor once said: "Thought under Scientific Management is 75 per cent analysis and 25 per cent common sense."

When a seemingly difficult operation has been analyzed to its last detail, it is not so difficult to reconstruct it on the proper lines. There is, too, an added interest to the management in the feeling that it is working on a plan, the underlying principles of which are already determined, and the details of which are to be developed in accordance with those principles more and more finely as years go by.

It has been my pleasure to have employed a number of young college men. Before they start to work, while they are in the only impressionable period that exists after they leave college — that is, when they first come under the eye of the manager — I tell them that had I known or realized the comprehensive plan of work under which I am working now, an equivalent of three years of the hardest work I have ever done could have been saved. The hard work would not have been saved, but I should have been saved three years because I should have been working on a plan rather than groping around in the dark and formulating plans many of which have had to be abandoned.

Probably many of you will say, "That sounds all right, but is not fitted for my business." I was very much interested to talk with a man who is the editor of one of the most progressive magazines, who told me today that he had been using some of the apparatus which he had seen in use under Scientific Management. His work is editing. Editors have always said that their work is not subject to Scientific Management because their work does not deal with systems, — their work deals with brains. I was much pleased to have him tell me that he has constructed a bulletin board in his office with which he is planning his editorial work, so that already he has done four months' work in one month and is up here for a two weeks' vacation, or somewhere for a two weeks' vacation, because he has that time which he never had had before under the old working conditions. Besides this saving in his own time he has reduced the amount of money invested in a mass of paid articles, and now buys such only as are required for a given edition.

Beneath all this there is a good deal of philosophy. It seems to me that this is the best solution of a fair compensation for labor because it puts a premium on the efficiency of both employees and employer, and the success of Scientific Management depends upon this close coöperation of employer and employee. Along some such line it seems to me will sooner or later be worked out the great problems of labor and capital.

THE SCIENCE OF MANAGEMENT

By Lieutenant G. J. MEYERS, U. S. N.

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When we consider any activity in life which has something definite for an object we call the direction of the process through which we accomplish that object, management. Management is the application of skill or care in the conduct of an enterprise or operation. Most people have considered that there are various kinds of management — poor, indifferent, fair, good or excellent. But it has never been considered that these various qualities of management depend upon the violation or non-violation of certain laws that belong to management and make it a science.

The quality of management is usually measured by the results accomplished and by its cost in time and money. Since it is possible to manage any activity and to obtain the most successful result, some laws must govern this successful management. The laws of any science are based upon experiments to determine relations between certain phenomena. This is so in the science of management as well as in the sciences of chemistry, physics, engineering. Theories are not being considered, but laws based on experiment, practice and common sense, and accepted as laws because of their success when applied to the subject they cover. To show that management has its laws and that the observance of them will bring about the most successful results and reduce to a minimum losses of time and money is the object of this paper.

Success cannot be obtained in management any more than in other sciences if the laws that govern it are violated. The quality of the management depends, then, on the extent to which its laws are observed.

The laws as here recorded are not the result of an arbitrary summing up of how an activity should be managed, but are deduced from a careful analysis of the management of several successful manufacturing companies. After applying them carefully to these companies they have been applied to activities ranging from the cooking of a meal to the conduct of a war. And it is necessary to emphasize the fact that these laws when applied give most successful results; and, *vice versa*, where successful results are obtained it will be found that these laws are applied.

Some objection has been made to treating the laws in the following form, omitting methods. To any one who has had any experience in management it is perfectly obvious that to record methods or procedure would be more than a life work. Every industry has its own methods, and in every branch of every industry different methods are required. In three successful machine shops visited by the author each had different methods of carrying out the laws, though each was engaged in machine metal work, manufacturing different lines of machines, and all three were equally successful.

What has been attempted is to put the subject of management in a form such that it can readily be understood by any one engaged in managing without hiring an "expert" or spending most of his time in reading what has been written on "Scientific Management," and to show that there is a wide difference between the laws and principles of management and the method of carrying out these laws. The methods are very often stated as fundamental principles when they are not. It is hoped that any one who is managing may, by carefully observing the laws in his business, soon evolve or find the methods that are best suited to his business.

It must be remembered that there are cases where not all the laws can be applied in all their details, but that in these cases, were it possible to apply them in detail, a nearer approach could be made to perfection of results than if the laws were neglected.

SYNOPSIS OF LAWS

I. What to do.
II. Instructions before work starts.
III. Machines and tools.
IV. Workmen.
V. Insure instructions are carried out.
VI. Costs.
VII. Study for improvements.

Law I

It is necessary in any activity to have a complete knowledge of what is to be done and to prepare instructions as to what is to be done before the work is started.

It must always be known what object is desired to be accomplished before starting work. For example: 1. In constructive manufacturing it is necessary first to design the finished product and to issue drawings of the design. 2. In the manufacture of chemicals or compounds it is necessary to state what the finished product is to be and to write down the specifications of the finished product. 3. In the case of professional work it is necessary to designate the object; for example, in medicine, a patient is to be cured of disease or sickness, and it is necessary to record either on paper or on the brain what the cure is to be. 4. In any one-man activity it is necessary to state the object that it is desired to accomplish; for example, in inventive or experimental work the ultimate purpose should be known as nearly as possible before work starts. Very often it will be found that the stating of the object is the same as writing the instructions as to what is to be done.

Whenever the first law of management is applied loss of time and money is eliminated as follows:

What is to be done is planned before the work starts and the laborer has only to follow directions. He need not stop to think what his past experience in similar cases has been, nor need he consult with a foreman and lose time in that way, but his instructions what to do are definite. The management is not paying a man to do a certain kind of mechanical work and requiring him to occupy his time in designing something he is not fitted to do. If the workman is losing his time in thinking about what should be thought out for him, and not accomplishing what he is hired to do, he is increasing the time he gives to producing his work and thereby increasing costs and reducing output.

If we do not know what we want to do or if we do not tell the workman what to do there is a vast amount of misapplied effort, there is a groping for something, which means that no effort is applied through a space of time; there is the idle workman we are paying who is waiting to be told what to do, and wasting time in studying the poor instructions he often does receive even after he thinks he has started on the work. All of this means waste of time and waste of money.

As this law demands that the object of any activity should be stated and instructions covering what to do should be written, it is obvious almost without explanation how this law is applied. As an example: A company manufacturing machines wishes to make one for a certain purpose. The order goes to the drawing room to design this machine; in issuing this order the object is stated. The drawing room then designs the machine and commits the design to paper in the form of general plans and detail plans; thus the instructions what to do are written.

Law II

It is necessary in any activity to prepare detailed instructions for each operation that goes to make up the whole as to how, when, where, and in what time each should be performed, what tools, and what materials to provide before work starts, and to transmit these instructions with the necessary tools and materials to the workman before the work starts. The stock of material on hand should not be allowed to fall below a certain minimum determined by the rate of output.

This law covers the planning of each operation and routing it through the shop. It simply means that the determination of how, when and where the work is to be performed, and what materials and tools to provide, is taken out of the hands of the workman and foreman and put into the hands of the planning department, where all the data as to the date of delivery, past methods, etc., can be drawn on to make accurate and definite instructions. The work is planned and instructions are given after a careful study from past experiment and practice as to the best way in which to do that work. Here the judgment of the laborer is eliminated. The amount of time and money saved in this can be judged by considering that every workman if left to himself will do the work according to his judgment, and it will be found that there are as many ways of doing a piece of work as there are workmen to do it. The chances, then, are that a large majority of the workmen are not doing the work in the best way.

The application of the second law of management will tend to improve the methods of the workman and to reduce loss of time in the following ways:

1. The time the work is to be started is planned before the work starts, so that in producing a complicated machine the parts are finished as they are needed to make up the whole. The workman who is fitting the parts or whose work depends upon the finishing of some part by others need not remain idle while he is waiting for the others to finish a needed part. Thus erecting work or work depending on other workmen will not be interrupted by allowing guess work to determine when the work is to be started, and, consequently, the calculations as to when the finished product is to be delivered to the purchaser will not be guess work. The instructions as to when the work is to be started are definite and exact, and are made with due regard to the work as a whole and to keeping all machines equally busy, and they eliminate losses in time due to delays and confusion.

2. The machine at which the work is to be done is indicated in the instructions after careful study before the work is started, having regard for the suitability of the machine and for the even distribution of work among the machines. This results in eliminating loss of time due to confusion and idleness at any one machine, and the instructions covering it are made definite and exact before the work is started; none of this is left to the judgment of the foreman or the workman.

3. The time which it should take to do any piece of work is transmitted to the workman before the work starts. This time is based upon careful time study of previous operations where all unnecessary motions have been eliminated. It should be a reasonable time in which the work can be completed over and over again for a year, if necessary, without spurting but with the man working at his normal or rational capacity. It is fixed also with regard to the quality of the work desired.

4. By having the tools and materials for each job provided at the place the work is to be done before the work starts the loss

due to idleness of machine and of workman while the tools are being brought is eliminated. The tools and materials are definitely stated in the instructions for each job, and the tools and materials for one or two subsequent jobs should be ready for the workman to proceed promptly on those jobs.

5. All instructions are made concise, exact and easily understood, and are at the place at which the work is to be done, so that before a workman is through with one job he has on hand, in addition to his tools and materials for the next job, the written instructions as to what he is to do, how, when, where and in what time he is to do it.

The elimination of losses of time explained in the last five paragraphs may be said to be the result of planning and issuing of instructions for any job before that job is started and are covered by Law II.

On the other hand, if Law II is not observed losses are increased as follows:

1. If the workman does not know how he is going to do a certain thing he is going to waste considerable time finding out, and is going to take up a great deal of his own time and of the time of some one else who should be otherwise engaged, and, finally, if he thinks he can do it without definite instructions, we are relying on his judgment as to how it should be done, which may be wrong.

2. If the workman has no instructions as to when to start a piece of work he is likely to let the most important piece go and take up any other at hand, or he may rely upon the judgment of the foreman as to when it should be started. In either case if we are, for example, constructing a machine, one part of the machine may be neglected until all others are ready for assembling. Then the unfinished part must be rushed through to the neglect of other work, and in the meantime our erectors are waiting, and the customer is not getting his machine when it was promised him. A little thought will show what confusion and loss of time will result from this practice.

3. If the workman has no instructions as to where the work is to be done, work is likely to crowd one machine and be slack at

another, much to the neglect of the work at the crowded machine and to the increase of confusion in the shop. Machines are idle and men are idle, and, as in the last paragraph, the finished product is delayed in leaving the shop.

4. If the workman does not know what time he is to consume on a given piece of work he will probably increase the number of unnecessary motions for that work and thus increase the amount of time it takes to do it. This results in loss of time and money. And there may be further loss due to the workman loafing at his work. This is perhaps one of the greatest losses in modern manufacture, though other factors, as is readily seen, help to increase the total loss.

5. If the workman does not have his tools and materials ready to start on his next job before he is ready to proceed with it, there will be delay incident to obtaining the tools and materials. This also increases labor losses.

6. If the workman has not his instructions as to what to do, how, when, where and in what time to do it, before he is ready to start his next job, there is another delay incident to his getting these instructions either from the foreman or from the office. This again increases labor losses.

The application of Law II may be said to cover all the planning before the work in the shop is started. The planning is based upon the written instructions as to what is to be done which are made out under Law I. The functions of Law II will be as follows:

1. Write instructions as to where the work is to be done. This should be done by analyzing the instructions as to what is to be done and dividing each complete job into groups and determining in what machine the operations in each group should take place and the order in which they should take place in relation to one another. This is done by the route clerk.

2. Write instructions as to what materials and tools should be issued for each operation covered in (1). This is done by the material and tool clerk.

3. Write instructions as to how each operation is to be performed. This is based on previous data properly classified for

ready use. These instructions are written by the instruction card clerk.

4. Write instructions as to the time in which work should be done with regard to standard quality. This information is based on previous data and time studies properly classified for ready use. These instructions are written by the instruction card clerk. Data is obtained by the time study clerk, if there is one, under Law VII.

5. The instructions are next collected and placed in a route file. This is the duty of the route file clerk, who places the instructions in the route file, arranging all operations for one complete job in an indexed file book and giving the instructions for each operation one page in this book. These instructions are now arranged ready for the work to progress through the shop.

6. Give instructions as to when work is to be done. This is done by the production clerk, who is over the other clerks in the planning department.

7. Instructions in one, two, three, four, five and six are finally transmitted to the shop by the order of work clerk (of which there may be several in a large shop) from the route files covering each complete job divided into various operations. The order of work clerk must necessarily be familiar with the machines and men in the shop and with information as to when the finished product is to be delivered.

8. The order of work clerk may have an assistant, whose duty it is to issue and receive operation cards to and from the workmen, and to record in the route file on the route sheet for each operation when the instructions for each operation are completed.

9. The tools are provided by a boy in the shop after the tool list is sent to the machine.

10. The materials are gotten ready for issue by the storekeeper before the instructions for work are sent into the shop. As soon as the materials are ready and the instructions sent into the shop an instruction card is sent to a move man in the shop to move the material to the place at which the work is to be done. This applies also to work done at a machine by one man, which must go to another machine and man for another operation.

11. The materials are checked as soon as the issue order is given to the storeroom keeper, by the balance of stores clerk, who never allows material on hand to get below a certain minimum fixed by the demand for each material.

In this way, then, the workman has instructions, tools and materials, at the place at which the work is to be done before the work starts and there remains only the operation order for the work to start, which is issued by the order of work clerk. When one operation is finished the next operation order is issued by the workman, and the work continues.

In considering the application of this law most manufacturers think that it requires too much clerical work for the object. It is not meant that one man is always necessary for each function under this law, but that each of these functions must be performed. For instance: the route clerk can write instructions for routing out material and can also issue orders and tool lists; the instruction card clerk can write instructions as to how to do work and act as time study clerk. The division of labor depends entirely on the nature of the activity and the size of the shop, having due regard to giving no man more work than he can expeditiously and efficiently handle.

Law III

It is necessary to provide for any given purpose before the work starts: (a) The best tools and machines for that purpose; (b) the best arrangement of machines in their relative positions; (c) machines and tools in the best possible condition.

Through experiment and practice in almost all industries machines and tools have been found that do better and quicker work than other machines and tools, and, in order to obtain maximum speed and highest quality of output, it is necessary that the best machines and tools should be provided and kept in the best possible condition at all times. It is evident that this requires that the machines and tools provided be of one standard — the highest.

It is desirable to arrange machines with regard to the work they perform, in order to reduce time and labor cost of moving work from one machine to another.

By applying this law losses are reduced as follows:

1. The best machines and tools are provided for doing any job. This means, for example, that a machine that will do two operations at once is better than the machine that does them in succession, and that automatic machines are better in a great many classes of repeat work than hand-tended machines. And it means that there are tools that are best fitted for any particular class of work, and even of these there are some that have been found by experiment and practice to be the best tools. The best tools, then, should be the only ones kept in stock. It is evident, then, by having the best tools and machines, loss of time is eliminated by reducing the time of each operation or series of operations, and by improving the quality of the finished product and thus decreasing waste due to defects in the finished product.

2. Arranging machines in relation to one another so that time is not lost and labor is not increased by transferring work from one machine to another further eliminates loss of time and money.

3. By keeping the tools and machines in the best possible condition loss of time is eliminated; since the machine is able at all times to deliver its maximum power at its maximum speed, there is no necessity of changing the tool because it is not sharp or is soft, or is not the standard of the best, and the possibility of a machine breaking down in the middle of work and delaying that work and keeping the workman idle is minimized.

The application of Law III is as follows:

This law should be carried out partly before any work is done; that is, the best tools and best machines should be provided before the work is undertaken, by studying machines already in operation and seeking machines with the latest improvements. They should be arranged in the shop in relation to one another to make the progress of work from one machine to another as nearly continuous as possible.

While work is in progress the tools should be kept shaped and ground, the machines should be kept clean and in good working condition, and belts should be kept at a tension such that the machines will deliver maximum power at maximum speed.

A record of overhaul and repairs to belts and machines, and a routine for overhauling and testing will be found to greatly reduce breakdowns and consequent delays.

For testing, inspecting and overhauling belting there should be enough men to completely carry out the routine, but they should be kept busy during working hours on idle machines. When necessary, they should work during the noon hour and for an hour after work stops in the afternoon, they being paid extra for this time.

The general repairs, including care of belting, are carried out by a regular gang under the charge of a repair boss. Those repairs that are urgent are, of course, effected first, and a complete record of all repairs is kept in a place available to the production clerk.

Law IV

It is necessary in any productive work to (*a*) *select the best laborer for the work demanded,* (*b*) *to keep the laborer so selected at his work and at no other.*

Men should be selected for particular work who have abilities for that work; as a rule, they can perform that work better than any other. Where a man persistently falls down in the quantity and quality of his output he should be either discharged or transferred to work that he is better qualified to perform.

After a man is selected for and proved at any particular work he should not be required to do any other class of work. For instance, a machinist should be kept at machinist's work and not be required to do blacksmith's, messenger boy's or tool grinder's work.

Losses are eliminated by applying Law IV as follows: The man best qualified should be selected for the work, having due regard to the cost of his labor. It is evident that it would be poor policy, and would result in poor workmanship and loss of time, to employ a blacksmith for a machinist's job, or to employ a machinist at machinist's wages to do the work of a messenger boy. It is important to keep a workman at the work he is required to do. It is evident that money and time are saved by employing a low-priced boy to carry the tools and materials to a high-priced machinist, and by keeping that high-priced machinist employed at machinist's work every minute that his labor is being paid for.

Law IV may be applied as follows:

The selection of the best man for work must be based on a consideration of the man's trade, the kind and class of skill required for the work, and, above all, the physical fitness of the man for the work.

Law V

It is necessary in any activity to assure that instructions are carried out as work progresses as to (*a*) *what is to be done,* (*b*) *how,* (*c*) *when,* (*d*) *where,* (*e*) *in what time work is done,* (*f*) *whether tools are provided,* (*g*) *whether materials are provided,* (*h*) *whether tools and machines are kept in best possible condition.*

It is as necessary for the management to know whether the instructions it issues are carried out as it is to issue instructions. Each function of this law may be carried out by a man detailed for the purpose, or two or more functions may be performed by one man. The methods may be selected, depending on the industry, and on the decision of the improvement expert, after a careful study of the men, the functions and the methods.

By applying Law V losses are reduced as follows:

1. Having bosses in the shop. If the workman is slow in setting up his work the gang boss should instruct him to improve his time; if a workman does not follow the instructions for speed the speed boss should show him how the instructions should be carried out and the work done faster.

2. As a further incentive to having instructions carried out, particularly as to the mannner and time in which work is to be done, a bonus is offered to the workman to do the work in the time allotted and to produce a standard quality of work. This incentive tends to reduce the time in which to do any job, and results directly in a high bonus to the owners as well as better wages for the laborer.

3. In order to prevent waste due to poor workmanship an inspector examines the finished product and requires it to be of standard quality. If it is not, the workman loses part of his bonus for fast work; this reduces loss due to poor workmanship.

4. Finally, a routine for overhauling machines and for reshaping and grinding tools will insure that the machine and tools are kept in the best possible condition; records are kept as to whether or not this routine is being carried out, and in all cases where breakdowns occur immediate repairs are made and reported. Usually the repair and upkeep of tools and machines would be performed by men who do nothing else. This eliminates loss due to breakdowns and failure of machines to deliver their maximum power at maximum speed.

In its application this law bring us back to the work in progress in the shop and is a connecting link between the shop and the production clerk. It requires reliable men in the shop to see that work progresses according to the instructions and to report on this work, and will include the following functions:

1. Proper tools and materials supplied.
2. Work is set up properly.
3. Instructions as to speeds, depths of cut, speed of cut, etc., are observed.
4. The work is done in specified time.
5. That machines and tools are kept in best condition.
6. That finished product is of a standard quality.

These functions are performed by —

1. Gang bosses, who inspect and report on the functions (1), (2) and (5).
2. Speed bosses, who inspect and report on the functions (3) and (4).
3. Inspectors, who inspect and report on (6).

The same rule applies here as under Law II, that the functions that are performed must be regarded, and that it is not necessary to have a man for each different function. That will depend on the class of work being done and the size of the plant. For example: the gang boss and speed boss are one and the same in some machine shops where work is just sufficient to keep one man busy, but not so busy that part of his duties are neglected.

Under this law comes also the question of a bonus which, as previously stated, is given to workmen to insure that instructions are carried out and the quality of the finished product is up to the standard, or, in other words, that the workman is delivering the amount and quality of labor that the management is paying for. Bonuses will not be here discussed, as any one desiring information on the subject can easily consult Emerson, Gantt, Taylor or Day.

Law VI

It is necessary in any activity to keep definite, reliable records of costs, and to be able frequently to summarize costs.

This law hardly needs an explanation, as it is self evident. In order to simplify the cost-keeping, reports should be constantly going to the cost department as material for each operation is issued and as each operation is finished, so that on any day the cost data on work going through the shop are complete. The only way in which the management can form an idea of the business is by summarizing cost frequently.

If we neglect to keep a definite and reliable record of costs we will have no knowledge of how we can sell, or if we are turning out work at the maximum efficiency.

As the application of this law covers cost, which is a separate subject in itself, it will not be gone into further than to state that the cost clerk should constantly receive information as to the apportionment of material to a given job, and the labor reduced to cost performed on each operation of a given job, when the operation is completed. His data should be so complete that at the end of each month he can apportion costs to each job and determine the cost of manufacture of all finished products.

His notice that a job is to be done may be the receiving of the manufacturing order, and that the job has been started in the shop, the receipt of the " tickler " (carbon copy of manufacturing order) from the production clerk. From this time until the order is shipped he receives records of all costs covering that order, as material is issued for each operation and as work is finished on each operation. The method of giving him this notice need not necessarily be the one here suggested.

A further application of complete costs records is in the estimating of new work, or work that is not standard. The operation of this law should make it possible to reduce the difference between estimated and actual costs of work to 2 per cent.

Law VII

It is necessary in any form of activity for those directing the work to study for improvements of (*a*) *costs*, (*b*) *methods*, (*c*) *machines and tools*, (*d*) *product*, (*e*) *labor*.

In order to improve conditions as given under this law it is best to have an expert with assistants to study each detail. While improvements will often come from men who are carrying on the planning of the work and the work itself, it is better to have some one who devotes his entire time to the subject of improvements and who will examine into and act on any recommendations that come from the men either in the management or in the shop.

In studying labor the aim is to so treat the workman that he is satisfied and knows he is getting a square deal at all times. This is one of the most important functions of Law VII, and will result in decreasing the losses due to men quitting work or striking or loafing because they are disgruntled with the management.

Not to study improvements in costs, methods, machines, tools and product will result in so antiquating any business as to place it at the mercy of its competitors, due to loss of time in manufacture, loss of business through inability to reduce costs to meet competition, and loss due to decreased sales resulting from the poor quality of the finished product.

To ignore the study of labor and to disregard all its demands, almost its existence, except in so far as it helps to make money, is almost the same as business suicide. The concern that does this or allows it to be done will have strikes, discontented workmen and poor workmen, with large losses due to idleness of the machines.

The application of Law VII should be as follows: The improvement department will be directly under the general manager or general superintendent. Although the last law, it is one of the most important in that it deals with labor. Before discussing this function it must be stated that methods in the planning department and in the shop should be constantly studied for improvement. One method of doing this in some industries would be to make time studies. The machines and tools should be studied, and where changes can be made for improvement they should be made, having regard to interruption of the work. Finally the finished product should be studied in order to improve it; for example: by cutting out or simplifying parts, by improving the usefulness of the machine in performing its function, and, finally, by increasing the field of usefulness for the machine. This law will cover, for further example in some branches of industry, studying methods for utilizing waste products, as by treating them so that they can be cheaply turned into saleable products, and to find uses for these products.

Finally, labor should be studied to prevent antagonism of labor to capital by giving labor fair and square treatment. This object should be carried out by a department in charge of a man of greatest tact and diplomacy which should have charge of:

1. Employing and discharging labor.

2. Distributing labor throughout the plant.

3. Disciplining men for violations of rules and regulations. Rules and regulations should include punishments for various standard offences, such as loafing, drunkenness, insubordination, etc. The punishments should be uniformly enforced. In a large plant this will necessitate maintaining a police department.

4. Keeping records of all labor employed, with the past history of each man, if it is possible to obtain it.

5. Paying labor.

6. The benefit fund.

7. Washrooms, lunch rooms, etc.

8. Library and any other "uplift" ideas that are in operation.

9. Recommending devices and methods for preventing loss of life and property. This would necessitate in a large plant a fire department.

10. Intercourse with the men through their representatives to discuss questions concerning labor at certain stated times.

11. Adjusting differences between workmen, or between workmen and bosses.

12. Distributing men to reduce friction between them and to reduce as much as possible partiality on the part of the bosses.

13. Medical attendance on men who receive injuries in the shops. In a large plant this would necessitate a hospital.

14. Improving conditions in the shops so as to reduce strain on the workmen, such as ventilation, heating and lighting.

The Illinois Steel Company at South Chicago has a labor department that is a model of its kind, and should be copied by every large industrial concern in the country. Its adoption will undoubtedly result in the elimination of friction between capital and labor. The author has talked with managers of concerns where labor troubles are practically unknown, and in every case this last law was found to be carefully observed. On the other hand, where there is a total disregard of conditions from the standpoint of labor — in other words, where labor is not studied — strikes are frequent and, strange to say, are looked upon as necessary evils. In these shops, also, it will generally be found that the average quality of labor is very low, good men leave such places to go where they are better treated and where they are not thrown out of work through strikes and walkouts. These are usually caused by a blind desire on the part of the management to make money at any cost, in many cases on a highly watered capital, the dollar sign being the only thing on the horizon of the board of directors and the management.

There is one point in management that is very often lost sight of; that it, that two objects should not be stated as one in applying the laws of management. For example: If we stated the object as being the manufacture and sale of certain machines, confusion would immediately result. The manufacture of machines is a distinct and separate operation from the selling of machines, and each should be treated separately in applying the laws of management. Due regard should be given to the fact that the connecting link between the two is the exchange of information between them as to costs, rate of output, capacity of the manufacturing department, the number of sales, dates of delivery, capacity and size and character of the finished product, and new contracts as they are made.

To illustrate this more concretely, the company supplying electric current and gas to a large city performs several functions. Taking only the electric part of it, there are the manufacture of current, the selling of it, the buying and installing of motors, wires, lights, etc. These functions are so confused that it is often difficult for the manufacturing department to know exactly on what days the installing department will finish its work, consequently the selling department has difficulty in promising the delivery of the current. The proper way under the laws of management to conduct this business is to separate each function from the other and to apply all the laws of management to each, providing means for exchanging necessary information between the departments. Thus the functions would be separated into (1) manufacture, (2) selling, (3) installing; each being conducted separately from the other except in the exchange of necessary information.

The criticism has been made that Law VII conflicts with Laws III and IV in that the last two laws require that the best tools, machines and men have been selected for the purpose and eliminates the necessity for studying for improvements. There is no question that the best tools, machines and men may be selected this year, yet five years from now such improvements may have been made as would put a company out of business if it had not constantly studied for improvements and applied them as they are discovered. If the men are not improved by constant study and instruction, then human nature is not what it is accepted as being. The mere fact, though, that the most successful manufacturers are studing for improvement in machines and tools, and in labor, is proof of the existence of this seventh law of management, and that it does not conflict with Laws III and IV.

It has been said that it is time to stop talking of principles and to begin to show the application of them and the final outcome. The author claims that principles and laws have not been discussed before, but that methods, under guise of principles, fundamental principles, laws, and other names not belonging to them have been discussed. This paper for the first time records the laws of the science of management and gives a starting point to those who wish to discuss methods. As to the results obtained by this application, it can be said that to record them would be as big an undertaking as to record the methods of carrying out the laws. If the laws of management are carefully observed the results will be success — success as nearly perfect as can be obtained by human methods working with human beings.

Again the criticism is made that Law II will not apply to the inventor, or to the man engaged in scientific research; that the very fact that a purpose is formed to make a discovery, invention, or improvement presupposes that what is to be done and final results are unknown. The mere stating of the purpose, recording it on the brain or on paper, forms instructions as to what is to be done. Whether the invention is a mechanical one, or whether the discovery is a chemical one, in either case the inventor or discoverer must know the laws of mechanics or the laws of chemistry in order to obtain the most successful results. That the final result is known approximately must be granted, or the discoverer or inventor is working without a purpose. That the laws do apply to accidental discovery is not contended, but it is contended that, whether in invention or in scientific research, the greatest degree of success will be obtained by the person who applies the laws of management.

That Law II is too broadly stated in that it does away with all initiative on the part of the individual workman is another criticism that is made. The answer to this is left to the large number of successful employers engaged in productive work who require that the laborer carry out orders, and who do not give him a wide latitude in which to experiment on his employer's material and probably ruin it. It must be granted that the management knows what it wants done and how it wants it done, and that the work should be done according to its orders.

A reduction of the seven laws of management to diagrammatic form is shown in Fig. 1. This shows the simplest form of their

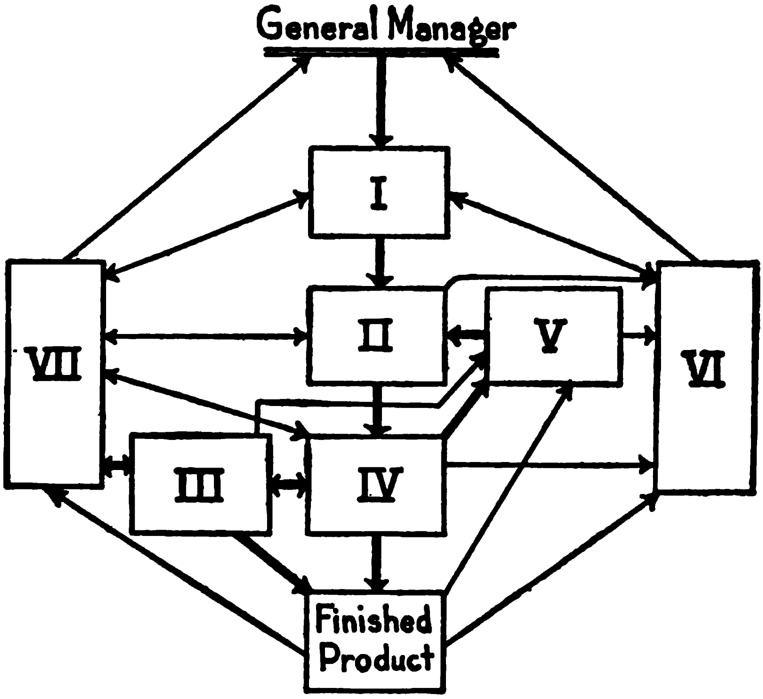

Figure I

application to any activity. The work progresses from the general manager to the estimating and drawing room (covered by Law I), to the planning department (covered by Law II), to the shop (covered by Laws III and IV). Law V is a connecting link between shop and planning department. Costs and improvements keep in touch with all (covered by Laws VI and VII).

In Fig. 2 the different elements are given their proper names. The planning department is placed within the shop, as it is in reality a part of the shop. In large plants such as the Allis-Chalmers Co., for example, each shop has its own planning department, while in a smaller shop such as the Tabor Manu-

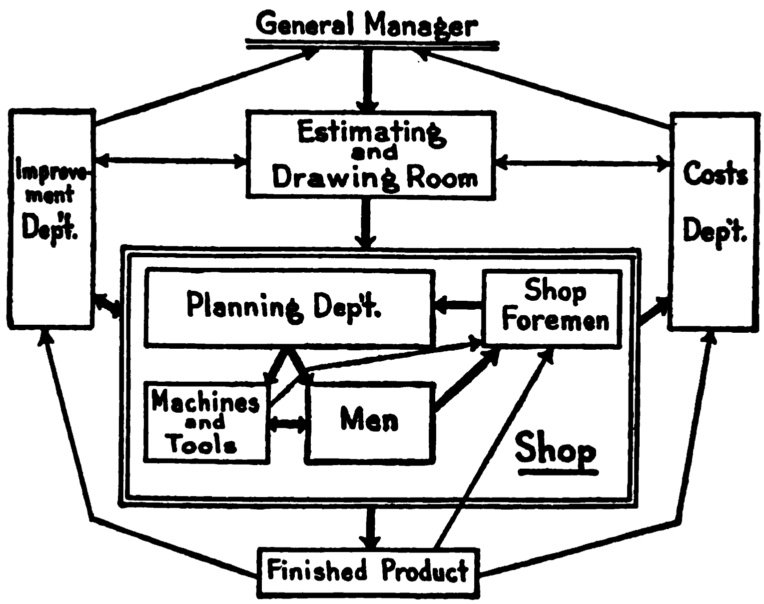

Figure II

facturing Co., there is one planning department for a shop employing about ninety men. The number of men requiring a separate planning department can only be determined by the size and nature of the industry and the arrangement of the plant. The Bement-Niles Works of the Niles-Bement Pond Co., for instance, has one planning department for about fifteen hundred men, and successful results are obtained.

THE PRESENT STATE OF THE ART OF INDUSTRIAL MANAGEMENT

Majority Report of Sub-Committee on Administration of the American Society of Mechanical Engineers, 1912

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During the past few years a number of striking phenomena, in connection with industrial management, must have become evident even to the most superficial observer. The more important are:

(*a*) The widespread, popular interest in the subject which had its rise in a statement made before the Interstate Commerce Commission, in a hearing on the matter of proposed advances in freight rates by carriers. An attorney for the shippers stated on November 21, 1910, that it was estimated that by the application of newly discovered principles of management " in the railroad operation of this country an economy of $1,000,000 a day is possible," and further that these principles can be applied with equal success " in every form of business activity." This popular interest is shown by the great number of articles published in the daily papers and popular magazines, mediums that give but scant attention to technical subjects, except of the most striking nature.

(*b*) The suddenly intensified interest in the subject on the part of employers and business executives in many lines of activity, shown by lectures, addresses, professional papers and reports presented to their associations.

(*c*) The opposition of labor unions to the newer methods of management, shown by statements of labor leaders, in a few instances by strikes and by an attempt to prohibit by law the use of some of these methods in Government shops.

(*d*) Governmental recognition of the matter shown by the appointment of a special committee of the House of Representatives to investigate systems of management in Government arsenals and shops, which reported in March, 1912; by the appointment of a civilian board by the Secretary of the Navy to investigate management in the navy yards, which reported in July, 1911; and by Senate bill *S 6172*, now in committee, which is intended to prohibit time study and the payment of premiums or bonus on Government work.

(*e*) The rapidity with which literature on the subject has accumulated. One directory of books on business management lists 500 titles, and states that 75 per cent of them have been written within five years.

(*f*) The formation of two societies having as an aim the furtherance of the application of the principles of management.

(*g*) The separation of persons interested in the matter into two camps, one of enthusiastic advocates, the other of vigorous opponents of what is called the new element in management.

(*h*) The unquestionable proof of the advance that can be made in unskilled work, as shoveling material, and in ancient trades, as bricklaying, by the application of the principles of management. This is the most striking phenomenon of all.

The Principles of Manufacture

2. Before defining the element in the art of management that has given rise to these phenomena, it is necessary to review briefly the beginnings of modern industry. This gives a historical setting from which the present can be more truly judged.

3. Modern industry is stated by some writers to have begun in 1738 when John Wyatt brought out a spinning machine. Others place the period as between 1750 and 1800, when the power loom and steam engine came into being. It was marked by the development of labor-saving machinery. It was brought about by the change from handicraft to manufacture.

4. Early British economists held that the application of the principle of division of labor was the basis of manufacture. From Adam Smith's *Wealth of Nations*, 1776, we quote:

> This great increase of the quantity of work which, in consequence of the division of labor, the same number of people are capable of performing, is owing to three different circumstances; first, to the increase of dexterity

in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labor, and enable one man to do the work of many.

5. Charles Babbage, the great British mathematician and mechanician, believed that from the above-quoted statement the most important principle was omitted. This omission he supplied as follows in his *Economy of Machinery and Manufacture*, 1832:

That the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill and force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided.

6. It appears, however, that another principle is the basic one in the rise of industry. It is the transference of skill. The transference of skill from the inventor or designer to the power-driven mechanism brought about the industrial revolution from handicraft to manufacture. It will be necessary to refer to this principle frequently throughout this report, in showing the meaning and position of management in industry.

7. No better single illustration of the application of this principle can be found than in the invention of the lathe slide rest by Henry Maudsley in 1794. This has been ranked as second only to the steam engine in its influence on machinery building, and thus on industrial development. The simple, easily controlled mechanical movements of the slide rest were substituted for the skilful human control of hand tools. So complete has been this transference of skill that today hand tooling is a vanished art in American machine shops. Very few lathe hands can chase a thread with hand tools, yet all can cut good threads on an engine lathe, thanks to the slide rest. After the traditional skill of a trade, or the special, peculiar skill of a designer or inventor, has been transferred to a machine, an operator with little or no previously acquired skill can learn to handle it and turn off the product.

8. An example of the extent to which this transference of skill is carried today is presented by the shoemaking industry. The United Shoe Machinery Company builds some 400 machines used in shoe manufacture. These are so highly organized that the greater part of shoe shop operatives are unskilled except in a single readily mastered detail of the work. The skill in shoemaking is now in the mechanical equipment of the shops. This transference is a development of the past 50 years.

9. James Nasmyth, a British engineer, inventor of the steam hammer, has this to say in 1851 of the application of this principle in his own works: "The characteristic feature of our modern mechanical improvements is the introduction of self-acting tool machinery. What every mechanical workman has now to do, and what every boy can do, is not to work himself, but to superintend the beautiful labor of the machine. The whole class of workmen that depend exclusively on their skill is now done away with."

10. Methods of analyzing and recording operations were early developed. Adam Smith records the divisions of the work of manufacturing pins, listing 11 operations. Charles Babbage gives a table (see Appendix No. 1, Table 1) from a French investigator, showing the number of operations, time for each, cost of each, and expense of tools and material for making pins in France in 1760. He gives a similar table for English manufacture in his day (see Appendix No. 1, Table 2, from *Economy of Machinery and Manufacture*, 1832).

11. He further comments on the use of the watch to time operations. We quote from his instructions to one making such observations and using a skeleton form that he recommends: "In filling up the answers which require numbers, some care should be taken: for instance, if the observer stands with his watch in his hand before a person heading a pin, the workman will almost certainly increase his speed, and the estimate will be too large. . . . The number of operations performed in a given time may be frequently ascertained when the workman is quite unconscious that any person is observing him. Thus the sound made by the motion of a loom may enable the observer to count

the number of strokes per minute, even though he is outside the building in which it is contained."

12. M. Coulomb, the noted French physicist (1736–1806), who had great experience in making such observations, cautions those who may repeat his experiments against being deceived by such circumstances. We translate a single quotation: "I pray (says he) those who wish to repeat them (the experiments) if they have not time to measure the results after several days of work, to observe the workmen at various times during the day without their knowing that they are being watched. We cannot be too well warned of the danger of self-deception in computing either the speed or the effective time of work through an observation of a few minutes."

13. Thus we see the application of the principle of transference of skill at the basis of the development of the industry, and an early appreciation of the value of the detailed study of operations in making that transference more complete. But the machine was the viewpoint. It was looked upon as the producing unit. Combined and contrasted with this was a lack of knowledge of scientific principles and their sure application. Charles Babbage treats of this forcefully. We quote:

There is perhaps no trade or profession existing in which there is so much quackery, so much ignorance of the scientific principles, and of the history of their own art, with respect to its resources and extent, as is to be met with amongst mechanical projectors.

14. In the same vein he emphasizes the need of accurate drawings as if having in mind the poor quality of the work from the average draftsman of his day: "It can never be too strongly impressed upon the minds of those who are devising new machines (says he) that to make the most perfect drawings of every part tends essentially both to success of the trial, and to economy in arriving at the result."

15. He further points out that there is another important factor in successful industry, in addition to machinery. We read that "in order to succeed in a manufacture, it is necessary not merely to possess good machinery, but that the domestic economy of the factory should be most carefully regulated."

16. These quotations foreshadow modern methods of thinking out the work in advance and transferring this thought to the workmen. The subsequent development has had the effect of advancing still further the division of labor, and beginning the division of thought. The drafting room presents the first example of the trend, in its collection of engineering data, in its prediction of results and the formation of staff organization.

17. But from the period of the last quotation almost to the present there has been no change in the basic principles discovered and applied in industry. There has been nothing but an extension of those already known. The place of greatest advance has been in the drawing room. The art of machine design has been greatly developed. The last half of the last century saw a tremendous increase in inventions, a tremendous furtherance of the application of transference of skill to machines and tools. The skeleton of an industrial organization of this period, one that was too large for a single executive to manage, consisted of a designing department and a production department, each with a head responsible to the manager.

18. The first of these, the one that was the means of embodying skill in the machinery and tools of production, was highly developed and organized. Experiment, research and detailed study were constantly resorted to, to aid in reaching the desired result. The work was highly specialized and the employees highly paid. Not infrequently the manager or chief executive devoted much of his own time to this part of the business.

19. The production department presented a contrasting condition. The workmen were given the tools and machines designed in the drawing room and using their own unaided skill were expected to produce work of the desired quality and quantity. Except in rare instances no effort was made to transfer the skill of the management to the production department and the employees, or to undertake the division of executive thought. Very little consideration was given to the workmen as a producing unit.

Features of the Change

20. Within the past 20 or 25 years certain changes have taken place in the attitude of many production managers toward the problems that they face and the forces and means that they control. An increasing amount of attention is being given to the worker. An early evidence was the development of profit sharing, premium and bonus systems to reward increased effort and output. There followed welfare work, industrial betterment movements, the adoption of safeguards and regulations to minimize industrial accidents, the substitution of the principle of accident compensation for employers' liability and an improvement in the physical surroundings and conditions of factories. All of these tendencies have been fostered and to a great extent initiated by employers. But even today these are by no means generally adopted.

21. Another tendency, less pronounced in character, has as its object the improvement of the personal relations between employee and employee and between employee and employer. It is an effort to establish the best of factory working conditions in those things not physical in nature, to develop and maintain a shop atmosphere free from all harassing and hindering influences. It is an attempt to make use of the results of experimental psychology in improving working conditions.

22. But the most important change, and one that comprehends the others, is in the mental attitude toward the problems of production. The tendency is toward an attitute of questioning, of research, of careful investigation of everything affecting the problems in hand, of seeking for exact knowledge and then shaping action on the discovered facts. It has developed the use of time study and motion study as instruments for investigation, the planning department as an agency to put into practice the conclusions drawn from the results of research, and methods of wage payment which stimulate coöperation.

23. All of these changes have affected the production department much more than the designing department. The effect is to extend the principle of transference of skill to production, so

that it completely embraces every activity in manufacture. The skill of the management is consciously transferred to all of the operations of the factory. This extension is expressed by these phrases: the drawing room is the planning department of design, and the planning department is the drawing room of production.

Nature of the Committee's Investigation

24. To obtain information on present conditions your committee wrote to the recognized experts, to executives of plants in many lines of industry, to students of industrial problems, and has had many interviews with men in these various fields. The response to our requests has been in the main most generous. We are deeply indebted to the information thus received for a large portion of the following sections of this report. We are glad to take advantage of this opportunity to express our gratitude to all those who have given aid.

25. Throughout the following pages there is a plentiful use of illustrative quotations. Many of these are taken from correspondence resulting from our investigations. Others are from the mass of literature mentioned in Paragraph 1*e*.

26. On some points diametrically opposed views have been expressed. In such cases we have presented both. In no case has credit been given for these views or quotations, as the information was solicited in confidence.

Definition of the New Element in the Art of Management

27. Requests for a definition of the new element in the art of management brought forth a difference of opinion as to its existence. The opposed view is given in the following quotations:

> I am not aware that a *new* element in the art of management has been discovered ——.

> There have been no new discoveries in scientific management of industrial institutions. Common-sense men have used common-sense methods always. The term "scientific management" is a catch-word which assumes that industrial institutions have not been scientifically managed — which is not the case. My experience and the experience of my friends has been that there has been no new element injected into the art of management.

In the writer's opinion there is very little that is new about it (the art of management). There is hardly any part of it that has not been practised by managers for the past 100 years. The trouble is there are not enough managers with sufficient initiative to set the system moving properly.

—— the problem presented is not the adoption of something entirely new; but rather the extension to every detail of our work of something which we have already tried.

28. Turning now to the other side of the question, from a large number of definitions of this new element we select the following as very nearly conveying, taken together, the complete conception as our investigation has disclosed it:

The best designation of the new element I believe to be "scientific management." This term already has been adopted quite generally and although frequently misused, carries with it the fundamental idea that the management of labor is a process requiring thorough analytical treatment and involving scientific as opposed to "rule-of-thumb" methods.

The writer ventures to define the new element briefly, but broadly, as: The critical observation, accurate description, analysis and classification of all industrial and business phenomena of a recurring nature, including all forms of coöperative human effort and the systematic application of the resulting records to secure the most economical and efficient production and regulation of future phenomena.

Stripped of technicalities the method of the modern efficiency engineer is simply this: First, to analyze and study each piece of work before it is performed; second, to decide how it can be done with a minimum of wasted motion and energy; third, to instruct the workman so that he may do the work in the manner selected as most efficient.

The Taylor System is not a method of pay, a specific ruling of account books, not the use of high-speed steel. It is simply an honest, intelligent effort to arrive at the absolute control in every department, to let tabulated and unimpeachable fact take the place of individual opinion; to develop "team play" to its highest possibility.

As we conceive it, scientific management consists in the conscious application of the laws inherent in the practice of successful managers and the laws of science in general. It has been called management engineering, which seems more fully to cover its general scope than a science.

29. These quotations convey the ideas of a conscious effort to ascertain and study facts and systematically to apply them in instructing the workmen and in controlling every department of industry. Setting these against the underlying principle of the transference of skill we conceive the prominent element in pres-

ent-day industrial management to be : The mental attitude that consciously applies the transference of skill to all the activities of industry.

30. Here emphasis is placed upon the word *all* for, as shown in Paragraphs 17 and 18, the restricted application of this principle to machines and tools has been highly developed for a long period. But its conscious application in a broad way to the production departments, and particularly to the workmen, we believe has been made during the last quarter century.

Rise of this Mental Attitude

31. The rise of this change of attitude in regard to industrial management is shown in the papers on the subject in the Transactions of this Society. These are 16 in number and are listed in Appendix No. 2 of this report. The period covered is from 1886 to 1908. The practice upon which several were based extended over a number of years before the paper was presented. Papers on accounting have been excluded.

32. The first, No. 207, classifies management of works as a modern art having a vast amount of accumulated experience, points out that the executives must have " a practical knowledge of how to observe, record, analyze and compare essential facts in relation to . . . all . . . that enters into or affects the economy of production and the cost of the product," and makes a plea for the interchange of management data.

33. Eight following papers, Nos. 256, 341, 449, 596, 647, 928, 965 and 1012, deal with methods of wage payment, showing the increasing attention given to the workmen during this period. Of these methods the " premium plan " described in paper No. 449 has an extensive use today in machine shops. It probably ranks third, in extent of use, being exceeded by day work and piece work in the order named. Paper No. 647 outlines elementary rate fixing; that is, the minute study of each detail of each operation. From this, motion study and time study have grown. The " bonus system " of paper No. 928 also has an extensive use, probably ranking fourth.

34. Paper No. 1003, "Shop Management," is the first complete presentation of the subject. This paper with the subsequent writings of its author, stands today as the only comprehensive outline of industrial management. Papers Nos. 1001, 1002, 1010, 1011 and 1115, are amplifications of certain features of No. 1003 and are based on the same practice.

35. Paper No. 1221 deals with the training of workmen, and outlines practical, tested methods of bringing about the all-important transference of skill.

Labor-Saving Management

36. Since these papers were presented, and during the development of popular interest in the subject, the term "scientific management" has been generally and loosely applied to the new system and methods. This is commonly taken to mean that there is a science rather than an art of management. A truer interpretation is that it means management using scientific methods, these being taken largely from the sciences of physics and psychology.

37. The expression "labor-saving management" better conveys the meaning of the movement. It has the further advantage of being easily and surely understood because of its strict analogy with the term "labor-saving machinery." It is no chance that puts these two terms labor-saving machinery and labor-saving management, in conjunction, for the first is the past development and the second the present trend of industry, and they will be closely and inevitably associated in the successful manufacturing of the future. Throughout the following pages of this report the terms "industrial management" and "labor-saving management" are used, the first to denote the subject broadly, the second the newer attitude.

The Regulative Principles of Industrial Management

38. The lack of accurate thinking and clear expression in regard to management are nowhere better shown than in many of the statements of the so-called principles. These can be divided into two classes, personal characteristics of managers

and mechanical means of applying. It is evident that neither can show us the way in which the activities of industry are to be regulated.

39. In our investigation preparing for this report, one correspondent writes as follows:

The regulative principles of management along scientific lines include four important elements:

(*a*) Planning of the processes and operations in detail by a special department organized for this purpose.

(*b*) Functional organization by which each man superintending the workman is responsible for a single line of effort. This is distinctly opposed to the older type of military organization, where every man in the management is given a combination of executive, legislative and judicial functions.

(*c*) Training the worker so as to require him to do each job in what has been found to be the best method of operation.

(*d*) Equable payment of the workers based on quantity and quality of output of each individual. This involves scientific analysis of each operation to determine the proper time that should be required for its accomplishment and also high payment for the worker who obtains the object sought.

40. Another correspondent finds the solution of problems of management in the observing and regulating of three classes of industrial phenomena:

(*a*) The economic results of different arrangements and forms of materials and operations upon them, either to produce equipment or product. This covers the whole field of recorded experience from invention and design of product and tools down through the successive shop processes to ultimate finished product and its tests in service. It is the object of the scientific method to make the best of this experience, in its essential details, readily available for all concerned, and to see that it is actually absorbed and put in practice.

(*b*) The economic results of varying executive methods for effectively directing human efforts as a whole in the use of the above experience. This covers the entire field of building up, coördinating and controlling the supervising organization of a plant with its statistical and recording systems.

(*c*) The economic results of steps taken to raise the industrial efficiency of the individual worker in every grade of service. This covers the whole problem of labor reward, intensified ability, conserved energy and the general relations of employer and employee.

41. We have pointed out that the underlying principle, that is, cause in the widest sense, the application of which has built

up modern industry, is the transference of skill. This basic principle is put into effect on the management side of all industrial activities, through three regulative principles which sum up the ideas in the above quotations, Paragraphs 39 and 40. These have been concisely stated as:[1] (*a*) the systematic use of experience; (*b*) the economic control of effort; (*c*) The promotion of personal effectiveness.

42. The first includes the use, in all essential detail, of traditional knowledge, personal experience and the results of scientific study on the part of the executive force. It implies the accumulation and use of records and the setting up of standards.

43. The second includes the division and subsequent coördination of both executive and productive labor; the planning of single lines of effort, the setting of definite tasks and the comparison of results; and the effective training of the workers. It implies the previous acquisition of skill by the executives.

44. The third includes a definite allotment of responsibility and the adequate, stimulative encouragement and reward of both executive and productive labor; the development of contented workers, and the promotion of their physical and mental health. It implies the most thorough comprehension of the human being.

The Practice of Management

45. As labor-saving management springs from a change in mental attitude, the beginning of its practice should be with the persons having the final responsibility, the proprietors of closely-owned businesses, the directors of larger establishments, or the officials having charge of Government works. Before any changes are made, such men should clearly understand the viewpoint from which all of the managerial work is to be done, the principles that are to be applied, the general method of their application and the results expected.

46. A similar mental attitude must be fostered among all the members of the executive force and a period of training for them begun. This may include a redistribution of function and

[1] *American Machinist*, vol. 36, p. 857, "The Principles of Management," by Church and Alford.

responsibility, and will include a detailed study of production by scientific methods. This is the period of division of thought, training of the management staff and setting up standards of performance. This must be carefully performed before there can be effective transference of skill to the workers in the production departments.

47. The usual conception of modern management is that it affects the workmen most of all, tending to stimulate them to turn out increased production to their possible hurt. This is wrong. If the principles outlined are followed, the executive, or non-producing labor is the most affected. Its individuals are compelled to study, plan and direct. They must acquire knowledge and skill in order to transfer it. It is a system of management that forces the executives to manage.

48. This being so, the introduction of modern management in a plant must be made slowly. The causes of most so-called failures are principally two: a failure of the executives to acquire the vital mental attitude and too great haste in application. The latter seems to be the dominant one. Your committee feels compelled to emphasize the danger of attempting to hurry any change in methods of management. Each step of the work should be made permanent before the next is begun.

49. We have examined records of production which clearly show a lessening of individual output among workers who had been trained for some time and had achieved good results as soon as untrained workers were put with them, thus lessening their share of personal supervision. Later the original standard of production was again reached, but the results seemed to be directly proportional to the amount of skilful supervision, during a lengthy period of training.

50. After those who are to operate the new methods have acquired the necessary knowledge and established sufficient standards, the work of putting these into effect can be begun. This means the fixing of the best attainable working conditions and giving each worker definite tasks with an adequate reward to each one who attains to the standard set. This part of installing the methods must be accomplished with tact and patience,

remembering that leadership and example are powerful aids in bringing about enthusiastic coöperation.

51. The training of the workers is essential in this part of the application. This must be far more than mere demonstration, the mere showing that a thing can be done. It must be patient teaching and help until the required degree of dexterity or skill is acquired, that is, up to the habit stage. It is evident that such work cannot be hurried.

52. Such, broadly, are the three steps in the practice of management. It is now necessary to investigate the internal elements of permanence in such methods. If the proper mental attitude is once taken, we believe it will never be given up. This is substantiated by a few cases when early attempts to improve management were failures and the methods abandoned. Later, however, other attempts were made with substantial success. The mental attitude outlived the failure. Thus in a given industrial organization this feature would not be lost except by a loss of the executive staff.

53. The permanence of records of performance and standards needs only to be mentioned to be appreciated. Once set up in an industry, disaster is invited if they are disregarded.

54. To these is added a third in the nature of a spur from the working forces to the managing force. An adequate reward is one of the essentials. Whatever disturbs the mechanism of production interferes with the earning of the rewards. The workers at once object, pointing out the trouble and insisting that it be rectified. The management is spurred to keep all conditions up to the fixed standard. Examples of this action have been brought to the attention of your committee.

55. The practice as outlined, while built upon fixed standards and procedure, is by no means rigid and inflexible as has been alleged. The design and construction of labor-saving machinery is carried on with a multiplicity of different details. Labor-saving management should likewise use a variety of details suited to the requirements of different industries and plants. There can be nothing fixed in such human endeavor except the underlying principle. As a simple matter of fact we have found

different methods, details and nomenclature in use in different plants. Many efforts have undergone marked change and development since first installed. Further, this idea of rigidity is repudiated by some of the foremost management experts.

56. In Paragraph 39 is emphasized the need of a scientific study of everything connected with production. The methods used are adapted from the research laboratory. But the purpose of their use is changed. The scientific investigator uses his laboratory to discover facts. Their discovery and declaration is his end and aim. The management investigator uses laboratory methods to discover facts for immediate use. The end and aim is utility. This is the test of industry. It is therefore unwise and in fact detrimental to carry investigations to an extreme. Enough facts must be observed to shape intelligent action. Persons having time study and motion study in charge should possess that rare, intuitive, human quality that causes its possessor to know when enough observations have been collected to form a sound working conclusion.

57. The position of the expert in the practice of management is more clearly seen as experience increases. The element of mystery has already departed. This is to be welcomed for it means the downfall of mere "systematizers." One of the unfortunate features of this great movement has been the rise of alleged experts who have been ready to promise extravagant results if they were allowed to systematize an industrial plant. The test which their work cannot meet is the one of permanence.

58. An industrial manager who has had signal success in directing large enterprises sums up the more undesirable characteristics of systematizing practice as:

(*a*) The publication and quotation of statistics regarding gains made through the use of particular systems, without a frank statement of the degree of inefficiency of the plants before reorganization.

(*b*) The failure to view the plant from the investor's standpoint rather than as a laboratory offering opportunities for interesting and expensive experience.

(*c*) The failure to admit that every application of past solutions to unstudied new and different conditions *is* an experiment.

(*d*) The waste of time and money on problems that will yield to scientific treatment, but which do not recur often enough to justify such a solution.

(*e*) The undervaluing of effective leadership in management and consequent lack of permanency in results.
(*f*) The overvalue of emasculated "system" leading to a curious non-responsibility on the part of any person for the total result.
(*g*) The frequent assumption that the treatment of the problems of similar plants should be identical.
(*h*) The failure to properly appraise in a growing concern the value of its internal asset of "good-will."
(*i*) The imperfect analysis and appreciation of the human factor in industry, with a consequent failure to reckon patiently with "habit" and "inertia" and a tendency to hasty "substitution," bringing about the breaking up of valuable organization.

59. The real expert concentrates on the facts of a given problem, and from a wide experience in analysis, coördination and practical responsibility works out a solution by scientific methods, suited to the material and human factors involved. The tendency is for him to do less of the detail work of installation, but to train and direct the persons who are permanently to manage. This is a true process of transference of skill.

Statistical Data

60. Your committee hoped to present statistics on the extent to which labor-saving management is in use. This could not be realized. Many industrial managers whom we have addressed have not honored us with their confidence in this direction. In fact, it seems as if a secretive stage is now with us. There are two reasons for withholding such information. The first is identical with the one that has developed "trade secrets" and secretiveness in regard to machines, tools and processes, the desire to keep things of value away from competitors. The second is a belief that in the minds of some persons a reflection is cast upon the ability of the executives of an industrial establishment if outside experts are employed. Frequently a system of management is referred to as the development of some one in the organization, although it was installed by a management expert, employed for the purpose.

61. Some idea of the variety of the industries in which labor-saving management is in use can be gained from Appendix No. 3, which lists a total of 52.

Broad Results of Labor-Saving Management

62. In cases where the use of labor-saving management can be considered a success, the broad results have been: a reduced cost of product; greater promptness in delivery with the ability to set and meet dates of shipment; a greater output per worker per day with increased wages; and an improvement in the contentment of the workers. This last item is shown by the fewness of strikes under the new management, and in the refusal of those working under the changed conditions to join in a strike of their fellows in the same plant who were not working under the new methods. This last-mentioned situation has arisen a number of times. In one case an attempt was made to strike a room where about one-half of the operators were under the new conditions. These refused to go out; the rest went.

63. These results indicate certain advantages to both employer and employee. But it is charged that the movement has not yet entirely justified itself from the economic viewpoint, for it has not reduced the cost of product to the consumer. The implication is that its possibilities will not be realized until employers, employees and the public are alike benefited. With this view we are in most hearty accord. Labor-saving machinery has brought the comforts that we all enjoy today. Labor-saving management promises to extend those comforts. Where properly administered it is conserving labor and is thus contributing to the good of society at large, and although the benefit to the consumer may not yet be generally felt, it has already developed to a certain extent and will continue to develop as the natural result of increased production.

Members Sub-Committee on Administration

J. M. Dodge, *Chairman*,
L. P. Alford, *Secretary*,
D. M. Bates,
H. A. Evans,
Wilfred Lewis,
W. L. Lyall,
W. B. Tardy,
H. R. Towne.

APPENDIXES

Appendix No. I

64. The following tables are taken from a book published in 1832, *Economy of Machinery and Manufacture*, by Charles Babbage. Table 1 gives the cost and operations in detail in manufacturing 12,000 No. 6 pins in France in 1760. The observations were made by M. Perronet.

65. Table 2 gives similar data for manufacturing pins in England in the time of the author. The size is " eleven " of which there are 5546 to the pound.

Table I. Operations in Pin Manufacture in France in 1760

	Name of the Process	Time of Making 12,000 Pins, Hr.	Cost of Making 12,000 Pins, Pence	Workman usually Earns per Day, Pence	Expense of Tools and Materials, Pence
1	Wire	....	....	....	24.75
2	Straightening and Cutting	1.2	0.5	4.5	....
3	Coarse Pointing	1.2	0.625	10.0	....
	Turning Wheel[1]	1.2	0.875	7.0	....
	Fine Pointing	0.8	0.5	9.375	....
	Turning Wheel	1.2	0.5	4.75	....
	Cutting off Pointed Ends	0.6	0.375	7.5	....
4	Turning Spiral	0.5	0.125	3.0	....
	Cutting off Heads	0.8	0.375	5.625	....
	Fuel to Anneal Heads	....	....	....	0.125
5	Heading	12.0	0.333	4.25	....
6	Tartar for Cleaning	....	....	....	0.5
	Tartar for Whitening	....	....	....	0.5
7	Papering	4.8	0.5	2.0	....
	Papering	....	....	....	1.0
	Wear of Tools	....	....	....	2.0
		24.3	4.708		

[1] The expense of turning the wheel appears to have arisen from the person so occupied being unemployed during half his time, whilst the pointer went to another manufactory.

TABLE II. OPERATIONS IN PIN MANUFACTURE IN ENGLAND ABOUT 1830

	Name of the Process	Workmen[1]	Time of Making 1 Lb. of Pins, Hr.	Cost of Making 1 Lb. of Pins, Pence	Workman Earns Per Day	Price of Making Each Part of a Single Pin in Millionths of a Penny
					s. d.	
1	Drawing Wire.........	Man	0.3636	1.2500	3 3	225
2	Straightening the Wire..	Girl	0.3000	0.1420	0 6	26
		Woman	0.3000	0.2840	1 0	51
3	Pointing..............	Man	0.3000	1.7750	5 3	319
4	Twisting and Cutting the Heads..............	Boy	0.0400	0.0147	0 4½	3
		Man	0.0400	0.2103	5 4½	38
5	Heading................	Woman	4.0000	5.0000	1 3	901
6	Tinning, or Whitening..	Man	0.1071	0.6666	6 0	121
		Woman	0.1071	0.3333	3 0	60
7	Papering.............	Woman	2.1314	3.1973	1 6	576
			7.6892	12.8732		2320

[1] Number of Persons Employed: Men, 4; Women, 4; Children, 2. Total, 10.

Appendix No. II

66. Following is a complete list of papers published in the *Transactions of the American Society of Mechanical Engineers* dealing with industrial management: —

No.			
207	The Engineer as an Economist............	Henry R. Towne...	1886
256	A Problem in Profit Sharing...............	Wm. Kent.........	1887
341	Gain Sharing............................	Henry R. Towne...	1889
449	The Premium Plan of Paying for Labor.....	F. A. Halsey......	1891
596	The Relation of the Drawing Office to the Shop in Manufacturing.................	A. W. Robinson....	1894
647	A Piece Rate System.....................	Fred. W. Taylor....	1895
928	A Bonus System for Rewarding Labor......	H. L. Gantt.......	1902
965	Gift Propositions for Paying Workmen......	Frank Richards....	1903
1001	The Machine Shop Problem...............	Charles Day.......	1903
1002	A Graphical Daily Balance in Manufacture..	H. L. Gantt.......	1903
1003	Shop Management.......................	Fred. W. Taylor....	1903
1010	Slide Rules for the Machine Shop as a Part of the Taylor System of Management.......	Carl G. Barth.....	1904
1011	Modifying Systems of Management.........	H. L. Gantt.......	1904
1012	Is Anything the Matter with Piece Work ..	Frank Richards....	1904
1115	A History of the Introduction of a System of Shop Management.....................	James M. Dodge...	1906
1221	Training Workmen in Habits of Industry and Coöperation..........................	H. L. Gantt.......	1908

Appendix No. III

67. Following is a list of the industries in which some form of labor-saving management has been installed: —

- Book binding
- Building construction
- Carriage and wagon building
- Construction and repair of vessels (navy yards)
- Fire-arms and ordnance
  - Rifles
  - Gun carriages
- Machinery building
  - Automobiles
  - Agricultural implements
  - Coal-handling machinery
  - Electrical machinery
  - Founding, iron and brass
  - General machine work
  - Gas engines
  - Locomotives
  - Machine tools
  - Molding machines
  - Pumps
  - Pneumatic tools
  - Sewing machines
  - Typewriters
  - Wood-working machinery
- Metal and coal mining
- Metal working
  - Bolts and nuts
  - Chains
  - Hardware
  - Tanks
- Tin cans
- Valves and pipe fittings
- Miscellaneous manufacturing
  - Beer
  - Beet sugar
  - Boxes (wood and paper)
  - Buttons
  - Clothing
  - Cordage
  - Food products
  - Furniture
  - Flour
  - Glass
  - Lumber products
  - Pianos
  - Paper and paper pulp
  - Rubber goods
  - Soaps
  - Shoes
  - Slate products
- Printing and lithographing
- Railroad maintenance of motive power
- Steel manufacture
- Textile manufacture
  - Bleaching and dyeing
  - Cottons
  - Velvets
  - Woolens

Discussion

A. Hamilton Church. Turning to the majority report, we find that the prime underlying principle of management engineering is the transference of skill. This is an illuminative statement, and I venture to think, of great practical value. It is put very tersely in the sentence in Paragraph 8, " the skill in shoemaking is now in the mechanical equipment of the shop." That is a clear-cut picture of a change that is already complete, and it helps us to realize exactly what is meant by the transference of skill. It also helps us to understand why, in the engineering trades, there are such wide discrepancies in the amount of work turned out by individual operators. It is because, in these trades, the transference of skill is by no means so complete. For one thing, the capacity and range of the average machine tool is large, and to some extent indefinite. A considerable amount of skill is still vested in the worker. Still more, a remarkable amount of ignorance as to what the machine will or will not do is shared by the employer and the workman.

The report shows why this is bound to be so at the present stage. In the process of transferring hand skill to the mechanical fingers of the machine, the report emphasizes the fact that more attention has been devoted to designing it than to the problem of using it afterwards. It has been overlooked by the masters of industry that most machine tools are not specific but general machines, and that therefore a continuous study of the capacity and use of the machine is necessary to give effect to the skill stored up in it.

The more I think over this problem, the more I am convinced that the true line of progress is the exhaustive study of machines, their capacities and limitations. I have held this opinion for many years, and the system of industrial accounting I have been advocating for the past decade was, I believe, the first step made towards bringing forward the machine to its true place as a factor of production. But I must confess that until this principle of the transference of skill was brought out so clearly by this report, I did not realize exactly why the machine tool was frequently so surprisingly ineffective under indifferent handling.

I will pass over the acceptance by the committee of the three regulative principles of management, viz: (*a*) the systematic use of experience, (*b*) the economical control of effort, and (*c*) the promotion of personal effectiveness, which were worked out by Mr. Alford and myself, except to say that the credit for the formulation of these principles belongs in a larger degree to Mr. Alford than to me, and I will conclude my remarks by calling attention to a phrase used in Paragraph 51 of the report, viz: " the habit stage."

All the mechanism of organization in the world is valueless beside the steadiness of production that comes from the establishment of good habit throughout a plant. I will go further, and say that the whole object and end of organization should be to create the right kind and degree of habit in every one of the persons engaged in production, from the president down to the shop sweeper.

It is not enough for the workman to be so instructed that he forms good habit. Every living link in the chain of production requires equally to be so trained that his acquired habit is harmonious with all the rest. The report has mentioned this aspect of the question where it insists that the executives and not the workman are the persons most important to be reached. Few people understand that the principal work of an expert organizer is not the designing of elaborate blanks and cards, but the fostering, with tireless patience, of correctly adjusted habit in each member of the staff.

As the new ideals of management engineering appear to me, and this view seems confirmed by the committee's report, they may be summed up in three sentences:

Take nothing for granted.
See that every effort is adapted to its purpose.
Cultivate habit.

These sentences are, of course, merely practical derivatives from the three regulative principles referred to in the report. Each of them in turn implies other things which will readily suggest themselves. Thus, the possibility of cultivating correctly adjusted habit depends obviously upon proper mental and physical conditions for the living forces. It implies " lead " and not " drive."

It is an interesting question where the new spirit that we find abroad in industrial management has come from. To some extent, I think, it is part of a larger movement, the realization of a sense of social solidarity, of social responsibility of each for all, that is so marked a feature of the times. But it also arises, in part, from another cause. Scientific men tell us that the great difference between a savage race and a highly civilized one is that the former remains in a condition of natural innocence, and the latter has arrived at self-consciousness. This, I think, is the real state of affairs in regard to management engineering. We are passing from a stage at which there was a simple and unconscious following of tradition, into a stage of self-consciousness in which we are moved to subject our habits and our motives to severe self-scrutiny, and examine afresh every item of our daily practice. It is a very painful stage to have arrived at. Most of us are so content with our comfortable natural innocence that we do not like to part with it, but it is a process that, once commenced, must continue.

The examination into new methods of remunerating labor, the adoption, with caution, of searching instruments of analysis, such as time study, the use of precise methods of accounting — these are not causes, but consequences, of this newly awakened self-consciousness. It is beginning to be recognized that production is an aggregate of infinitesimal separate acts, in each of which there are three main components. First, experience must be drawn on; secondly, the resulting effort must be intelligently adapted to the end in view; thirdly, this intelligent effort must become habitual. And to secure the successful performance of these acts, the living forces concerned must be maintained in the pink of condition, both mental and physical.

C. B. THOMPSON. A fact not to be ignored is that labor, organized and unorganized, has taken its stand, at least temporarily, in opposition to the development of scientific management.

While many of the objections raised have been so unreasonable as to be abandoned almost from the start, there are three criticisms made by working men which persist in spite of explanation: In the first place, they seem to cherish an innate resentment against time study — "putting the stop watch on them," as they express it. It "makes them nervous," "makes them speed up unduly while under inspection," "is simply another means of slave driving," "is used unfairly," "is un-American." They say also that the method of minute planning in advance and of specific instructions as to details, is destructive of the initiative which has been the backbone of American industrial progress. Further, they assert that the enhanced product due to these methods is not fairly divided between the management and the men; that an increase of 400 per cent in production, as in the classic case of Schmidt, the pig-iron handler, has been accompanied by an increase of only 60 per cent in wages.

It is neither wise nor expedient to pass by these criticisms without comment. That they are all unmerited may perhaps be shown: for instance, it has been demonstrated that time study, carried on by one who is trained in the subject (and whose training is ethical as well as intellectual), is not unfair, nor is it used as a new method of driving, nor is it in any sense un-American. Time study has been carried on for decades in psychological laboratories for purely scientific purposes and with instruments even more refined than the despised stop watch, but no one suggests that this use is open to criticism. When it is once clearly understood that time study in an industrial establishment, made under the proper conditions and by the proper persons, is aimed at similar scientific results, and that these results are then to be applied to work, subject to the mutual consent of employer and men, based on a conviction of their reliability and essential justice, these objections will disappear. But on the other hand, there is no doubt that time study can be and has been abused, and the working man has a right to be "shown."

Similarly in regard to the alleged destruction of initiative. Here the facts are clear. The machinist does not consider his initiative restrained when he is asked to do his work in accordance with the drawings supplied him by the drafting department. Systematic routing and planning of work and the development of a science by which it shall be done are, as the committee points out, analogous, for the production department, with the working drawing. We all believe in liberty, but we recognize, or are capable of being shown, that true liberty is liberty under law; that the artist is not in the least trammelled in his genius because he has been taught the laws under which he must use his materials; nor is the citizen any the less free because he, in common with all others, must conduct himself in accordance with the law of the land.

The problem of just distribution of the increased product is not capable of easy solution and demonstration, and much yet remains to be done in this field. No one has yet solved the problem of justice in distribution, and it does seem somewhat hypercritical to allege against scientific management that it has not done what any other movement or individual thus far has not been able to do. Rather it should be given credit for having pointed out the industrial necessity of justice in distribution, and of having proposed steps in that direction. The solution of this problem is not to be looked for from engineers. When an engineer wanders into the field of economics, he is apt to make about the same diverting spectacle that the economist would who would undertake to expound the principles of machine design. Probably the wages question will be worked out in the future as it has been in the past by neither the engineer nor the economist, but by the daily struggle and adjustment known as the "higgling of the market." In this struggle the rights of the working men will have to be conserved and enforced by organization. Only by pooling their strength can they meet the superior strategic position of the employers.

The report of such a committee as this should not have overlooked the opportunity to begin or extend the campaign of education in these particulars. Something more than education is necessary, however. Labor unions are a potent and active force in present-day industry, and we should get their enthusiastic coöperation. They are the culmination of decades or centuries of development. In spite of their numerous mistakes and injustices they have, on the whole, justified their existence; and whether you agree that they have or not, they are a condition and not a theory that confronts us. It would seem to be the part of wisdom, therefore, not to take the tack of ignoring or combatting the doubts and questionings and opposition of the labor unions, but rather to persuade them of the advisability of acquainting themselves with the facts, of recognizing the inevitability of the march of labor-saving management, and to secure their active coöperation in its development. A proposal at this time to retain their positive help in the extension of scientific management may seem Utopian, but it is warranted by certain facts and precedents in the history of trade unions. They have already established their right to determine the lighting, heating and ventilating facilities of establishments in which their members work. There are cases on record in which they have required owners of old plants to scrap their obsolete machinery and install new and modern devices, in order that the owners themselves may make sufficient profit to pay adequate wages to their employees. It is but one step, and a short one, in the extension of this principle to say to the owner that he must modernize his establishment in every detail, not because the working man is interested in the owner's personal profits, but because only such an establishment can pay the working man the wages which his standard of living demands.

The objections of the working men are naturally grounded in their personal experience and interest. The criticisms of the "friends of labor," however, are in most cases disinterested; though it must be said that in too many cases they are based upon a faint acquaintance with the facts. So far as they are disinterested, they must be recognized and met. It is sheer folly to adopt the attitude of the "hard-headed business man" and display a lofty contempt for the increasing interest in the welfare of the working men, which has been developing into a powerful force during the last century. "Hard-headed" is too often a mere euphemism for hard-hearted. Intelligent humanitarianism is not only legitimate but is one evidence of upward progress, and is neither to be ignored nor treated with contempt.

But business men have a right to ask the humanitarians that they be intelligent and informed. It is the business of business men to supply the information needed from the data which are usually at their exclusive disposal. When, for instance, it is alleged that scientific management is "dehumanizing," the charge should be met with the actual histories of men who have worked under this system. Many plants where it has been developed can show, on the part of their employees, an increase of leisure, of interest in their work, of knowledge and improvement in general character, and an enhancement of all-round welfare. Mr. Taylor, and especially Mr. Gantt, have not ignored this side of the subject; but, in proportion to the mass of data in their hands, their contributions have not been full enough. This committee must have had an opportunity to look into this side of the case; and it is to be regretted that they have not improved it more fully.

In a remarkable book, *Fatigue and Efficiency*, by Josephine Goldmark, published by the Russell Sage Foundation, a chapter is devoted to The New Science of Management: Its Relation to Human Energies. In this chapter are pointed out the advantages of the new methods from the point of view of the working man. After enumerating the perversions to which scientific management may possibly be put, the author says: "If the unscrupulous use of scientific management were all that could be charged against it, the system could defend itself easily enough. . . . More serious is the contention that the efficiency engineers themselves have failed to gauge fairly the tax of increased productivity upon the workers. . . . What we need as regards both men and women (and the only answer which will allay the suspicions aroused by scientific management) is more knowledge as to the ultimate physical adjustment of the workers to the heightened intensity of their tasks." And lest this seem to have too philanthropic a sound, I hasten to add the word of a prominent manufacturer, William C. Redfield, of Brooklyn. He says: "Once for all, let it be said that no management is scientific or permanently profitable which either promotes or permits human overstrain, or which taxes the future of women and children." This reflects, I think accurately, the judgment of many thinking people. The problem of the health of employees is one which demands and must have adequate consideration. No one who knows scientific management at first hand can deny that it has been given such consideration by those who are entitled to class themselves as scientific managers. Miss Edith Wyatt's investigation of the subject with reference to women workers, the results of which are described in Chapter 7 of the book by Clark and Wyatt, *Making Both Ends Meet*, is conclusive on this score (and incidentally is somewhat misrepresented in Miss Goldmark's discussion). Numerous instances of the effect of this work on the health of employees might have been collected by the committee and should be given.

I know of a case of a girl who asked to be put on a task 50 per cent greater than what she had theretofore performed. At the time she appeared to be in a sickly condition. The factory nurse was consulted as to the advisability of allowing her to undertake the task and gave her consent on the condition that the girl be allowed to go back to her ordinary work if at the end of a fair period it was evident that the task was too severe for her. After the expiration of four weeks the nurse reported (and it was already evident to the manager) that the girl was not only doing the task easily but had greatly improved in health. This, in the nurse's opinion, was due partly to the improved condition under which the girl worked, to the better method she had been taught, to the higher wages she received and to her increased contentment. This same girl shortly afterward asked for an increase of 33⅓ per cent more in her task, but this was refused.

In this report the committee emphasize the "transference of skill" as the basic feature of the new labor-saving management. Unfortunately, however, it appears that this term is used with two meanings. Throughout most of the report it seems to mean the accumulation of skill by the planning department and its transference from this department by actual instruction to the workmen just as machinery is said to be the transference of skill, according to the report, from the designer and draftsman to the machine. The idea intended to be conveyed is undoubtedly right, but the illustration chosen is unfortunate.

Transference of skill, when considered with reference to the industrial revolution and the introduction of machinery, might easily be interpreted to mean the transference of skill from the workman to the machine. What actually happened was that the machine brought to the aid of the workmen some of the vast forces of nature; and in addition it superseded the skill of the hand worker. That this was a distinct loss to the hand worker who was unable to adjust himself to the new conditions is incontestable in the face of economic history; and the sad record of the change is a solemn warning to present day managers to take every step possible to make the adjustment to new methods of management as easy and gradual as possible. The machine developed a new kind of skill on the part of the operator; but now it is a minute skill easily acquired and subject to sudden loss with the change in the design of the machine.

The old-fashioned, all-round workman has disappeared or is rapidly disappearing; and though his replacement by the modern, keen-eyed, high-strung, quick-moving specialist is not to be altogether deplored, it has had certain serious consequences. It has made the present day operator narrower in his knowledge of industry and his skill less adaptable and elastic. It has also rendered obsolete the old methods of apprenticeship, and the present chaotic condition of this subject presents a striking illustration of the failure of managerial thought to bring about the necessary readjustments.

It seems to me important that the committee's meaning on this subject be made unmistakable. No one can reasonably and seriously object to the transference of skill to the workers by the " systematic development of a science " and " systematic training."

H. L. Gantt. The difficulty of making a satisfactory report on the present state of the art of industrial management can be thoroughly understood only by those engaged in the installation of the new methods. The committee have caught fully the present spirit of the movement now in progress, and Paragraphs 45 to 58 of their report seem to me to be an excellent résumé of the subject.

In Paragraph 21, however, we find the following statement: "Another tendency, less pronounced in character, has as its object the improvement of the personal relations between employee and employee, and between employee and employer."

This tendency which is described as being less pronounced, I believe to be the most important part of the whole subject, for until proper relations are established between employer and employee, no system of management or training can be permanently successful.

When the methods described by the committee were first presented, many people thought that they were simply new schemes for exploiting the employee for the benefit of the employer. However false this impression may have been, it was undoubtedly widespread, and formed a serious obstacle to their introduction. How deeply rooted this idea was in the public mind can best be appreciated by reading the discussions of my paper on "The Training of Workmen."[1]

Since that time the prominent writers on the subject of management have emphasized the necessity of establishing proper relations between employer and employee, realizing that no scheme that does not recognize this as an integral part can be permanent. Unfortunately this has not yet been acknowledged by everybody to be a fact. Many people value these methods only as new ways of controlling workmen for their exclusive benefit, and become interested in them only in times of trouble. Financiers seem particularly prone to take this view.

To illustrate this point, about a year ago I was consulted by a large corporation, which, however, took no further steps. Recently the same corporation was much interested in the subject of management, and I found that its employees were on the verge of a strike. The strike, however, did not come off, and the

[1] *Trans. Am. Soc. M. E.*, vol. 30, p. 1053.

interest of the management apparently died out when the danger disappeared.

While the idea of exploiting workmen for some one's benefit is obnoxious to most people engaged directly in industrial pursuits, this is not the case with those farther removed from the workmen.

If I am to judge from the letters I received after the hearing before the Interstate Commerce Commission in Washington in November, 1910, many people thought they saw in this movement a chance to get something for nothing. So strongly was I impressed with the extent of this attitude that I felt impelled to condemn it most strongly in my address at Dartmouth a year ago. When I was leaving the hall after that address, a benevolent looking old gentleman came up and said: " Of course you will modify that before it is published ? " and I did, but not just as he meant.

I regret that the committee did not include in their bibliography of this subject, books and papers published elsewhere than in the annals of the Society, for some of the very best work on this subject has been done in the last three years, during which time the Society has nothing to show. I wish to call especial attention to the work of Major Hine on *Modern Organization* and to that of Hon. William C. Redfield on *The New Industrial Day*. Both of those books, just published, will well repay careful study, as they are in accord with the democratic as opposed to the autocratic spirit in industry.

With regard to the minority report, a careful reading seems to indicate that the writer of it is practically in accord with the majority, except that he wishes to take a shot at the statement made before the Interstate Commerce Commission that the railroads were losing one million dollars per day. I must confess that when this statement was made it seemed to me rather extravagant, but a careful study of conditions for the past two years has convinced me that the statement was conservative rather than otherwise if all preventable losses are included.

The writer of the minority report is connected with what I believe to be one of the most progressive and best managed railroads on this continent. I did a little work for him a few years ago, first, having in conjunction with Messrs. Dodge and Day of Philadelphia, made a report on the conditions in his shops. Our report expressed the opinion that his method of operating these shops was at least as good as that of the best railroad shops we knew anything about, and we visited several representative shops in this connection.

The real inefficiencies with which I came in contact on this road, however, were not in the shops. They lay in antique time-keeping, record-keeping, cost-keeping, and purchasing systems, which were run, not for the benefit of the maintenance and operating departments, but apparently to hamper these departments to the greatest possible extent. Inasmuch as most roads handle these functions in substantially the same manner, I believe that the inefficiencies of railroad operation, due to the lack of appreciation by the financial end of the needs of the operating end, are far greater than those over which the operating end has absolute control.

Railroads are built nominally to earn money for their stockholders by the sale of transportation. If this were the only way they could be used to get money, all activities connected with a railroad would be so run as to assist in the economical production of transportation, just as all the activities of a well run foundry are harmonized for the production of castings at low cost.

As a matter of fact, the financial end, including the purchasing, store-keeping, time, cost, and record keeping, does not as a rule consider economical operation as any of its affair, but puts this responsibility entirely up to the operating force. The best railroad managers of today, however, see that real economical operation cannot be had unless all functions contribute to that end, just as they do in the best managed factories.

Unfortunately this is a view that the average financier finds difficulty in accepting, especially if he has always been a financier. A proper comprehension of this subject, however, is the best way to head off the growing sentiment for the government ownership of railroads.

Turning again to Paragraph 21, concerning the relations between employer and employee, any scheme for the training of workmen, or promoting the transference of skill, if that term is preferred, to be ultimately successful must carry with it a guarantee on the part of the management that the employee shall receive his share of the product of his increased efficiency or skill. Increasing the efficiency of a workman thus differs radically from increasing that of a machine, which claims no share of the results.

If, however, the attempt to increase the efficiency of the workman is made in such a manner as to lead both employer and employee to feel that he is getting what he should from their mutual efforts, the promotion of efficiency is sure to follow, and we have a working basis on which to attempt the solution of some of our industrial problems. As long, however, as such prominent men as Mr. Parry and Mr. Kirby of the National Association of Manufacturers continue to use such language as they have in the past in speaking of workmen, just so long will the workmen continue to use brute force in dealing with employers, and a satisfactory solution of the labor problem be delayed.

The implication in the report of the committee that the development of methods and the training of workmen are functions of the management has to my mind not been sufficiently emphasized. The piece work system as usually operated, and most of the premium and bonus systems in general use do not recognize training as a function of management, and may be classed as individual effort systems. They have undoubtedly accomplished some results in the past, but we have now reached the stage in our complicated industries where more than individual effort is required. Individual effort may be so hampered by environment as to make progress impossible, and to cause the workman to become so discouraged as to give up whatever effort he may be making. On the other hand, if the management determines that a certain degree of efficiency is attainable, accepts the responsibility of training workmen up to the point necessary to obtain that efficiency, and provides means for obtaining it, we have an entirely different condition.

This view of the subject is so opposed to that held by most managers, superintendents and foremen that it is with great difficulty that we can get them to accept it, and the time needed to bring them around to this viewpoint is far greater than most realize. There are many reasons for this, and the fact that a man does not instantly accept a new proposition, which is to his mind revolutionary, should not for one minute be held up against him, for a strong man who has been successful in following one line of action, justly regards an entirely different line as being inferior to one which has brought him his success.

JOHN G. ALDRICH. I believe that the report of this Committee is right. Scientific or labor-saving management is scientific measurement and every one will agree that this is desirable. The importance has been pointed out in this report of the study of production by scientific methods and of setting up standards. It is impossible to make up standards without first making a careful study of the correct motions and of the times required to make them.

The New England Butt Company, of which I am manager, is doing some work along this line to which I would like to call attention. This company builds largely machinery for making braids, such as trimmings for ladies' dresses, shoe strings, coverings for insulated wires, etc. The machines are made up mostly of small light castings which are machined but little, but which must be well made so that the parts will fit together without filing or other hand work.

Within the last few years with the help of various experts we have continually made improvements in our manufacturing departments. Time study was made of different operations and of different methods and proper times were set on those methods upon which to base the various systems of payments for work performed. We are now using a method of time and motion study which has not been used before, and which not only gives more accurate results than have been heretofore possible, but also enables us to discover methods that are much more economical.

This method consists of taking motion pictures of the various operations with a special moving picture camera, and photographing in each picture a clock of special design showing minute divisions of time. The hand of this clock revolves once in six seconds so that the divisions represent thousandths of a minute and are easily read to half thousandths. The continuous motion picture film furnishes permanent record of times and motions. To develop improved methods this film is afterwards studied with a magnifying glass and it is not necessary to project the pictures on a screen.

Before taking these pictures considerable study was given toward eliminating waste motions and otherwise improving the conditions under which the work was done. In assembling machines, instead of picking up the pieces to be assembled from various boxes, packets were arranged with the parts placed in convenient positions, and also placed in the proper sequence, so that no mental process was required of the workman to determine or select the parts to come next.

Since using this method, which we have designated micro-motion study, previous times have been reduced over two-thirds. Its records have suggested to us methods that now permit in one case doing work in 8½ minutes that before using micro-motion study took 37½ minutes.

Paragraph 6 of the report calls attention to a most important principle, " the transference of skill." Micro-motion study furnishes a means for the transference of skill from man to machine. More important than this it furnishes a means for the transference of experience from a man who has had it to one who has never had it. We have used micro-motion study for determining the correct times of the best motions in many different kinds of work. It is the least expensive as well as the only accurate method of recording motion and time study data.

Micro-motion study enables us

(*a*) To capture the experience of the most skilled workman and record it for the benefit of all.

(*b*) To determine the motions of least waste.

(*c*) To teach the best known methods only.

(*d*) To analyze, measure and compare new data so that improved methods may be constantly standardized as fast as discovered.

I believe that the time will soon come when we will have a national bureau of standards of best methods, and micro-motion study will provide a means that the government can use for collecting and recording the best practice of the workmen in our industries.

Fred. W. Taylor. The preparation of this report has evidently involved careful research, followed by a close analysis of the materials gathered in. The viewpoint from which the whole subject is examined is new and original. Most writers upon this subject have emphasized the necessity of reducing to a science the knowledge which in the past has been in the heads of the workmen. The change from rule-of-thumb to scientific knowledge has been largely dwelt upon, and its importance pointed out. The thought of the committee, however, centers mainly about transferring this knowledge to the workman after it has been acquired by the management; and from this viewpoint scientific management is very properly summarized as " the mental attitude that consciously applies the transference of skill to all of the activities of the industry."

The Committee very properly calls attention to the significance of the change in the mental attitude of both sides which takes place under scientific management. This would seem to be the most vital element in scientific management. It was, indeed, looked upon as of such importance that, during the hearings before the House Committee " to Investigate the Taylor and other systems of management," man after man came from the shops which are being run under scientific management, to testify that the very essence of this system lies in the great mental change which comes both to the management and to the workmen. In fact, with but few exceptions, these men testified that without this complete mental revolution, scientific management could not exist.

This mental change is great and far-reaching. It means essentially a change from suspicious watchfulness and antagonism and frequently open enmity, between the two sides, to that of friendship, hearty good-will and coöperation. It means a change from the old belief that the interests of employer and employee are in many respects necessarily antagonistic, to the firm conviction that the true interests of the two are mutual.

This feature of scientific management is of such importance that it seems desirable to make one of the causes for the change in mental attitude a little more clear. The following illustration may help to do this:

Into the manufacture of any article there enter two items of expense, the cost of the materials of which it is composed, and the cost of what are commonly called "overhead expenses" or general expenses, such as the proper share of power, light, heat, salaries of officers, etc.

Now, if these two items of expense, cost of materials and general expense, be added together and their sum subtracted from the selling price of the article, we have what is called the "surplus." And it is over the division of this surplus between the company and the men that most of the labor troubles and disputes have come in the past. The men want as large a part of this surplus as possible in the form of wages, and the company as large a share as possible in the form of profits. And in the division of the surplus, under the older systems of management, both sides have come in many cases to look upon their interests as truly antagonistic.

A part of the great mental revolution that occurs under scientific management is the complete change in viewpoint of both sides as to this surplus; from looking upon the division of the surplus as the important question, they both come to realize that if, instead of pulling apart and quarreling over it, they join together and both push hard in the same direction, they can make this surplus so large that there is no need to quarrel over its division, because each side can get a far larger sum than they had ever hoped to get in the past. And each side realizes that this result would have been entirely impossible without the hearty coöperation of the other. The workmen see clearly that without the constant help and guidance of those on the management side, they could not possibly earn their extra high wages, and the management see that without the true friendship of the workmen their efforts would be futile, and they are glad to have their workmen earn much higher wages than they can get elsewhere.

The introduction of scientific management is, so far as I know, the first large movement in industrial history in which a great increase in the output of the workmen has been at once accompanied by a large increase in the earnings of the workmen. The great increase in output resulting from the introduction of labor-saving machinery was not at once accompanied by much if any increase in the wages of operatives, and in many instances the introduction of labor-saving machinery resulted in paying lower wages to the operatives of these machines than had been received by similar hand workers before the introduction of machinery. The main profit was absorbed at first in almost all cases by the manufacturers, who introduced the new labor-saving machinery. In the end, of course, the operatives, along with all the rest of the world, have profited immensely through the introduction of labor-saving machinery.

One of the most notable features of scientific management, however, is that the group of men who have introduced it have insisted that the workmen coming under its principles should at once be paid from 30 per cent to 100 per cent higher wages than they could get elsewhere. This fact is not appreciated by the general public, and largely because the labor leaders, consistent in their fight against the introduction of any labor-saving device, have seen fit to misrepresent far and wide almost all of the good features of this system; and in doing this they have strenuously denied that the workmen coming under scientific management are paid higher wages than heretofore. Quotations such as the following, taken from the famous circular distributed by President O'Connell throughout the Machinists' Union, are typical of this misrepresentation by labor leaders:

> Wherever this system has been tried it has resulted either in labor trouble and failure to install the system, or it has destroyed the labor organization and reduced the men to virtual slavery and low wages, and has engendered such an air of suspicion among the men that each man regards every other man as a possible traitor and spy.
>
> The installation of the Taylor system throughout the country means one of two things — *i. e.*, either the machinists will succeed in destroying the usefulness of this system through resistance, or it will mean the wiping out of our trade and organization with the accompanying low wages, life-destroying hard work, long hours, and intolerable conditions generally.

In answer to this statement of O'Connell's, however, in the sworn testimony given before the House Committee to investigate the Taylor and other Systems of Management there was presented a schedule of the present wages in comparison with the past wages of all of the workmen who had been more than 12 months in the employ of a company which was using scientific management. This statement showed that the workmen were then receiving on an average 73 per cent higher wages than when they first came under scientific management. The list of employees included all kinds, even the colored men who helped move the materials around the floor of the shop, and the sweepers, etc.

The testimony also showed that the company, after paying this 73 per cent increase in wages, found itself better off than it was under the older type of management. That fewer workmen were turning out three times the output formerly obtained and that the selling price of machines manufactured had been reduced 25 per cent.

It is object lessons of this sort which are rapidly convincing those who investigate scientific management that the interests of both sides are mutual instead of antagonistic.

The historical portion of the report shows careful study, and is evidently the result of much research. In certain particulars, however, it is somewhat misleading; that portion of it, at least, which includes the quotations from Adam Smith, etc., and particularly Tables 1 and 2, given in the Appendix.

Although the fact is not specifically stated, still the general impression from reading this part of the report is that "time study," which is the foundation for "the transference of skill from the management to the men," was practically carried on in 1760 and in 1830, as it is now under scientific management. This is, however, far from the truth, and in the interest of historical accuracy it may be desirable to make a statement as to the beginning of "time study," although I realize that questions as to who started time study, and when it was started, are of very little consequence, the important questions being, what is time study? and, how shall we make it more useful?

Time study was begun in the machine shop of the Midvale Steel Company in 1881, and was used during the next two years sufficiently to prove its success. In 1883, Mr. Emlen Hare Miller was employed to devote his whole time to "time study," and he worked steadily at this job for two years, using blanks similar to that shown in Paragraph 367 of "Shop Management."[1] He was the first man to make "time study" his profession.

It is true that the form of Tables 1 and 2, given in the Appendix to the Committee's report, is similar to that of the blanks recording time study, but here the resemblance ceases. Each line in Table 2, for instance, gives statistics regarding the average of the entire work of an operative who works day in and day out, in running a machine engaged in the manufacture of pins. This table involves no study whatever of the movements of a man, nor of the time in which his movements *should* have been made. Mere statistics as to the time which a man takes to do a given piece of work do not constitute "time study." "Time study," as its name implies, involves a careful study of the time in which work ought to be done. In but very few cases is it the time in which the work actually was done.

Previous to the development of "time study" in the Midvale Steel Works, there have in all probability been many instances in which men have carefully studied and analyzed the movements of other men, and have timed them with watches. (No such instances have, however, come to my personal attention.) Any such former work was without doubt confined to isolated cases, and was of short duration; and (most important from the historical point of view) it did not lead to the development of a new trade, or, more properly, to a new scientific occupation, "the profession of time study."

Any former efforts of this kind would bear the same general relation to the time study done in the Midvale Steel Works that the many early attempts at flying bear to the work of the Wright brothers.

The Wright brothers started "man flying."

[1] F. W. Taylor, *Trans. Amer. Soc. M. E.*, vol. 24, p. 1436.

The Midvale Steel Works started the "profession of time study."

(I do not of course intimate that the two developments are of equal importance.)

Time study is the one element in scientific management beyond all others making possible the "transfer of skill from management to men." The nature of time study, however, is but imperfectly understood and it is therefore important to define it clearly. "Time study" consists of two broad divisions, first, analytical work, and second, constructive work.

The analytical work of time study is as follows:

(*a*) Divide the work of a man performing any job into simple elementary movements.

(*b*) Pick out all useless movements and discard them.

(*c*) Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop-watch select the quickest and best method of making each elementary movement known in the trade.

(*d*) Describe, record and index each elementary movement, with its proper time, so that it can be quickly found.[1]

(*e*) Study and record the percentage which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, etc.

(*f*) Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.)

[1] Recording these movements so that they can be readily found is the most difficult element of time study. The writer threw away his first two years of time study because it was so poorly indexed that he was unable to find the elements when he needed them.

(*g*) Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, in order to offset physical fatigue.

The constructive work of time study is as follows:

(*h*) Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found.

(*i*) From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work.

(*k*) The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective; for instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, etc. And knowledge so obtained leads frequently to constructive work of a high order, to the standardization of tools and conditions, to the invention of superior methods and machines.

It is unusual to make a study such as this of the elementary movements of the workmen in a trade. The instances in which this has been done are still rare:[1] And it would seem that this must be due to a lack of appreciation of the great power which is given to the man who possesses a knowledge of the time value of these elements, and also to a lack of appreciation of the large variety of work to which these elements apply. How many men, for instance, know that a man who has received his education in "time study" through analyzing the elements of the movements of machinists engaged in manufacturing conveying and

[1] Most of the men who have made what they call "time study" have been contented with getting the gross time of a whole cycle of operations necessary to do a particular piece of work, and at best they have thrown out the time when the workman was idle, or evidently purposely going slowly.

hoisting machinery, can go with this knowledge into another establishment manufacturing machinery not in the most remote degree resembling hoisting machinery, and there use this knowledge to fix accurate daily tasks for the machinists? Yet during the past year and more, a young man trained in time study in the Link-Belt Works in Philadelphia, has been setting the daily tasks in one of our arsenals manufacturing a large variety of war materials, including the great disappearing gun carriages used in our coast defence.

Surely, when the significance of such a fact as this is appreciated, companies employing machinists, even though they may be manufacturing radically different kinds of work, will join together in studying the rudimentary elements of the machinists' trade and then in publishing this knowledge so that it may be available for hundreds of companies, where now it is the private property of the few concerns who have had the patience and the courage to be pioneers in this field. It is the lack of published data regarding the time required to perform each one of the elementary operations in our various trades (more than any other element) that makes the introduction of scientific management such a slow process.

If we accept the committee's definition of the new management as the "transference of skill from the management to the men," it is evident that the management cannot transfer knowledge and skill until they themselves possess this knowledge, and up to this time each new company introducing scientific management has been obliged to obtain this rudimentary knowledge through its own analysis and study, a very slow and tedious process.

Seventeen years ago, I predicted, in a paper read before this Society,[1] that books would be published similar to our engineering handbooks, embodying a time study of all of the elementary operations occurring in our various trades; and was then greatly laughed and sneered at for making this statement. Only one such book has as yet appeared, but I wish to repeat my prophecy with more emphasis even than before — that hundreds of books

[1] "A Piece Rate System," *Trans. Am. Soc. M. E.*, vol. 17, p. 856.

of this sort will be published in the future, and in the not far distant future. These books will make possible " the transference of knowledge and skill from the management to the workman " on a large scale throughout the country, and the introduction of scientific management will then indeed proceed at a rapid pace.

HENRY P. KENDALL outlined the experiments which have been worked out by the company with which he is connected, in the purchasing of labor, and spoke of the work of the employment man as a particular function in scientific management.

In this establishment this man engages the employees and tries to apply to them whatever physiological test he can to determine the kind of work each is best fitted for, or whether any particular one is fitted for the position for which he applies.

In employing women and girls, all are hired subject to the approval of the factory nurse, and if there is any question as to the health of men applicants, they are likewise passed upon.

So far as any person can judge, employees are given the kind of work for which they are best fitted.

The employment man's responsibility does not cease when he has hired the man. He has to follow his record in his work, and adopting a suggestion that came from James M. Dodge, cards are used to preserve the record of each employee. Four times a year information on each employee is added to these cards, as to how he is performing his work, his aptitude for it, his skill and earning power, and general deportment. He keeps in touch with each foreman or gang boss, and gets a signed report on each employee for these card entries.

The hiring and discharging and matters of discipline of the factory are all concentrated in the employment man, which prevents the injustice that comes from a gang boss or foreman discharging a man in a moment of anger and saying that he is no good. Should he say that a man was no good, and recommend his discharge, a written report from several quarters might contradict the statement, if it were unjustly made.

The training of young workers is especially important. There is nothing so discouraging to a boy as to be set to work at the end of school by an average foreman and forgotten. He may be in the wrong place and not fitted for that kind of work. He has, in the employment man, one to whom he can go for advice in regard to his present employment, for suggestions in regard to outside education or instruction, one who is in sympathy with him, and with whom he can rest his grievances and feel secure that he will not get in wrong with the boss.

The foremen at first thought they would lose their authority when they could no longer hire and discharge, but now they feel that it rather helps their authority to have the employment man to send to in cases of discipline. When a man is discharged by a foreman, although perhaps for cause, this may be done in an angry manner, and he may leave defiant, and with a determination to "get even." If instead, he is called to the office of the employment man and an explanation is given him as to why his services have not been satisfactory, and he is made to see that he is at fault, and if this is done in a quiet frank way, he leaves with an entirely different feeling. Under this present scheme, the employee is given an opportunity to register just complaints against a foreman, if he has any.

The purchase of machines and equipment has been strongly emphasized. The purchase of labor is more important, but is given less attention. Then, too, the main functions of scientific management can be used only in combination with other functions. This function can be adopted in any concern with equal advantage.

H. K. Hathaway wrote that the essence of this report lay in the phrase (Paragraph 29), "The mental attitude that consciously applies the transference of skill to all the activities of industry," further qualified by the statement, "the novelty of the new management lies in this transference of skill from the management to the workman."

This viewpoint is so novel that one is led to question whether the older descriptions of the essence of scientific management may not have been wrong. The committee, however, are merely laying emphasis upon one of the elements which has heretofore been looked upon as rather of secondary importance.

Before skill can be transferred, the management must gather in and record the knowledge and skill which were formerly widely diffused in the possession of a great number of workmen, and much of which was an almost unconscious inheritance. Gathering in and systematizing this knowledge ready for use, constitutes the development of a science to replace the old rule-of-thumb knowledge: this is what has been called by other writers the first of the four principles of scientific management, and this point the committee recognizes in Paragraph 47.

The writer's experience leads him to feel that the committee has not given sufficient prominence to the element of acquisition of skill or " the development of a science " as it has been termed. Such development goes farther than the acquisition of existing skill and results in additions thereto as well as improvement in methods and machinery, and the establishment and maintenance of standards.

It is impossible to transfer skill from the management to the workman first without choosing carefully the workman who is fit to do a particular kind of work, and then training him until he acquires skill: the second of the principles of scientific management. It is not only a transference of skill, but in one sense the creation of skill as well; perhaps a better expression would be the development of latent skill.

The third principle of scientific management has been called " bringing the science and the scientifically selected and trained workman together," which is merely another name for the committee's statement, " the mental attitude that consciously applies the transference of skill to all the activities of industry."

The fourth principle of scientific management has been defined as " an almost equal division of the work and responsibility between the management and the workmen. The management takes over all work for which they are better fitted than the workman, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men." This principle also follows directly the moment the management accept as their duty the first, second and third principles of scientific management. The burden of developing a science where only rule-of-thumb knowledge existed in the past, and the burden of training, teaching and transferring skill from the management to each workman in the place, of necessity calls for an almost equal division of the work between the two sides. So that in the one definition of the new science by the committee are implied all of the four principles of scientific management.

It might be proper to point out, in order to avoid misunderstanding, that specialization of workmen on one comparatively simple operation is not necessarily in accord with the best and most economic practice in management. It is a serious mistake and a disadvantage to have operators "unskilled except in a single readily mastered operation" as in the instance cited in Paragraph 8 of the committee's report. The writer's experience has been that it is not only generally desirable, but in many cases necessary to economy in manufacture, that each operative become skilled in at least two and generally more of the operations making up a process of manufacture. This is an objection to over-specialization purely from the standpoint of production.

Sanford E. Thompson. Criticism is frequently made of the amount of mechanism required to handle the work of modern management, the number of clerks needed, and the consequent increase in overhead charges, and to a visitor this increase in office is indeed more noticeable than the decrease in number of workmen or the increase in production.

If it were possible in a given establishment simply to make a few time studies and set scientifically accurate rates or tasks so as to obtain maximum production, no objection would be raised to the installation of scientific management, although it is obvious that if such a plan could be arranged, it would have long ago been adopted without resort to laborious study. Yet the criticism is heard so frequently from men of intelligence that it is worth careful consideration.

If we refer to the list of papers selected from the *Transactions*, and given in the Appendix to the report, it will be seen that those presented earliest discussed methods of setting rates for paying men. Following a short general paper by Mr. Towne in 1886, there are two papers on profit sharing, the least intricate form of incentive to the workmen; then from 1890 to 1903, the question of payment is discussed more in detail, the premium plan, piece rate and bonus systems; then come subjects relating more specifically to the more general problem, the management of the plant. It is evident from these papers that this sequence is not chance, but represents a development, not of theory but of absolute necessity in shop management.

A man who has made studies of workmen and introduced piece rates or tasks on accurate detail time study instead of by the usual "fix and cut" methods, finds that the very requirements of accuracy lead necessarily to standardization of methods. It is necessary to plan out the work of each man, to instruct him in the method so that he may use the least material and accomplish his work in the smallest practicable time, and to install a system of cards and records specially adapted for keeping track of the materials and the time of the men.

The development of what Mr. Taylor terms the mechanism of scientific management is thus seen. This development indicates that the broad general principles of planning, routing, instruction, scientific analysis, time study and standardization do not represent a mere system for which some other system may be substituted with equally good results, but a plan which is of broad application in management. These things appear to be fundamentally necessary for any organization which proposes to set rates and tasks which will give the men payments based strictly on the actual work which they accomplish, and which will enable them to do the work with the minimum waste of material.

The practical necessity for the introduction of these individual features is very plain to any one who makes a scientific study of any operation for the purpose of setting tasks.

These statements may be illustrated by one or two examples from actual practice:

Take the trimming of large sheets of paper to make ready for the press. The machine consists simply of a bed plate about 5 ft. sq. at a convenient level above the floor and an adjustable knife running across this bed plate and operated by power. The operator takes the paper, places it on the bed plate, makes the cuts and transfers the paper back to a truck: a very simple operation, lifting paper, cutting, lifting off.

When the work is studied with a view to putting it on the task basis, the following facts are discovered: the cutter is capable of going through a thickness of about 5½ ins. of paper. The size of the paper on the particular machine referred to is large, running up to 40 in. by 60 in. On account of the weight, therefore, the operator has to put it on in several lifts. Since the lift off is easier he is able to take it off in a fewer number of lifts. The number of lifts in both cases is not directly proportional to the weight. It is dependent also on the size, the stiffness, the thickness and the surface finish of the individual sheets of paper. It is readily to be seen, if a man takes six lifts where he should take four, as he naturally will do if he wishes to shirk, the time of lifting and therefore the cost of this part of the work will be 50 per cent too great. It is necessary, therefore, before establishing a task to standardize the plan of furnishing the paper. The paper was always counted, but instead of the usual plan of counting by hundreds, it is now arranged to divide the piles by slips of paper into individual lifts which a man should take.

For determination of the amount of lift and the other variables, special studies were required. These studies took rather more time and skill than the actual setting of the tasks when this preliminary work was accomplished. After the tasks were finally set and put into operation, it was necessary to throw out of commission the other cutter, which had been working on part time, and the only difficulty experienced was in finding work enough for this one cutter to do. As a result, the cost of the work was reduced 30 per cent with, at the same time, an increase of 40 per cent in the pay of the workman.

This is by no means an exceptional case. It is always necessary first to standardize the machine and the methods. It is this as much as anything else that differentiates scientific from rule-of-thumb methods. Usually the direct results of standardization produced even a greater saving than the actual task and bonus.

Another illustration may be taken from a shoe shop. In the cutting of leather, or in cutting linings from cloth, it is a simple matter to make time studies and determine the time required by the men to pick up the die and make the individual cuts. Piece rates may be easily set, based on the output of each cutter. Suppose, then, that this is done and such rates are set. The men immediately begin to " speed up," but in doing this without any restraint they naturally use more material than is necessary. Now, in the case that the writer has in mind, the raw material used in a certain shop during a week averaged $50,000 in value. The labor cost of cutting this material averaged $280. A 10 per cent reduction in the labor cost amounted to $28, while a 1 per cent reduction in material cost amounted to $50. Instead of gaining money by the setting of rates, the plant would actually lose money, because the men would waste more material. It was necessary, therefore, at the start, before setting any rates to attack the quantity side of the problem, investigate the best plan for layout of dies on the machine and establish some method for fixing the amount of material used by each man. This involved eventually a definite planning of each man's work, so as to show him how to use the minimum amount of material; a routing system, as an absolute requirement, which would properly deliver the materials to him and take away his product; and a system of instruction and time cards, so as to handle the work in the smoothest manner possible.

It may be claimed that these are special instances which do not often occur, but experience shows them to be very simple cases. Wherever a machine or an operation on construction work is studied thoroughly in order to eliminate unnecessary operations and the waste of materials so far as possible, similar methods must be gone through and a more or less complicated system adopted for the proper handling of the work. Only by such thorough study and investigation can the operation be reduced to a routine which will be essentially automatic.

MANAGEMENT PRINCIPLES AND THE CONSULTING ENGINEER

By CHARLES DAY

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Recently much attention has been directed to certain principles of management heretofore recognized by only a comparatively few as forming a distinct type of administration, wherein, to the greatest possible extent, scientifically ascertained fact replaces conclusions arising through inaccurate methods of deduction, and a liberal utilitarianism is the basis of all dealings with the workers.

Various papers presented before the American Society of Mechanical Engineers by F. W. Taylor, H. L. Gantt and others have kept engineers generally informed as to certain phases of this type of management, but the hearing before the Interstate Commerce Commission gave the country at large the opportunity for enlightenment through Louis D. Brandeis' able presentation of the subject, as well as the testimony of a number of those most capable of testifying to the efficacy of these principles.

The word " management " is capable of very broad interpretation, and the term " Scientific Management," which has been used so much of late, also covers a greater range in the application to which it has been put than appears to be generally recognized. Possibly it is on this account that I have been prompted to call attention to what I believe to be an intimate relationship between management work in the sense we are considering it and the diversified service performed by consulting engineers. The term " management " might not ordinarily be considered as appropriate to a kind of work that is closely allied to the service defined in the accepted sense by the word " Engineering." Nevertheless, the kind of management Mr. Brandeis defined is based not only upon the management of people, but the management of every important circumstance with which these people deal, and it happens that these circumstances are usually, in essence, of a strictly engineering nature.

The major part of the consideration so far accorded the subject has dealt with the principles themselves, and the mechanism or system necessary to carry them into effect when introduced into industrial companies by trained experts. These experts are consulting engineers whose work is highly specialized in character, and I desire to consider briefly the relations of their work, or more properly, the bearing that the principles advocated by them may have, upon the work of consulting engineers generally. This is a field well worthy of attention because of the broad educational influence which can be exerted by consulting engineers on account of the very nature of the service rendered by them.

The successful introduction of the managerial methods in question by any kind of manufacturing business should prove of very great benefit to the owners of the business, to the employees, and to those who consume the product; but the customers are to no appreciable extent enlightened as to the *methods* to which they owe the advantages that accrue to them. On the other hand, every client of the consulting engineer or architect, will, to some extent, become familiar with correct principles of management if these men have a proper realization of their bearing upon the work they are engaged to perform. The *product* of the industrial company may be almost identical, in so far as its usefulness is concerned, whether made under what we may term the old or the new systems of management, although, of course, in the latter instance it should be procurable for less money. On the other hand, the product in the sense of large and complex operations, resulting from the work of the consulting engineer, is likely to be quite different in character if it is worked up with a full recognition of the principles with which we are dealing (although not necessarily the ability to introduce these principles) rather than in the face of the serious lack of knowledge in this regard, now so general.

There are at least two distinct policies, either one of which can be selected by the consulting engineer, with, of course, many gradations between. He can confine his services either to work that he can personally direct in detail, which of necessity must be limited in its scope, or he can aim to build up an organization capable of handling, through its various members, a wide diversity of work, encompassing complete undertakings. The latter type of organization has had its principal development within the past ten years, being the logical result of the complex conditions with which the consulting engineer is confronted. Possibly the points I desire to bring out can be illustrated more clearly by dealing with the engineering organization rather than the engineer who works independently. As a matter of fact, what is said in regard to the organization applies, although in a lesser degree, to the individual, for the organization is but an aggregation of individuals. But for just this reason it presents within its own business the very problems that require, for their correct solution, these principles of management, an understanding of which becomes such a potent factor when handling clients' work.

There are in the United States today a large number of such organizations, several of which have attained enviable reputations at home and abroad. Their work can be broadly classified as dealing with industrial or public-service properties, and in some cases the same organization handles both of these classes of work.

Industrial-engineering work in its broadest sense comprises the following divisions, based upon the assumption that it has its origin, in all cases, in the desire to offer for sale a product for which there is believed to be a demand: *First*, thorough investigation as to the merits of the product from a commercial standpoint, taking into consideration every collateral factor such as the ability to finance the business, etc. *Second*, the performance of the detail engineering work incident to the provision of the physical accessories, such as buildings and equipment, needed in connection with the conduct of the business. *Third*, the actual provision of these facilities. *Fourth*, the organization of the working force, including the introduction of the mechanism required to assure the fulfilment of the principles of management which are necessary for the most successful conduct of the business.

Public-service engineering work differs but little from industrial work when each is considered in its broadest sense, for here we also find a demand for: *First*, the initial investigation as to the merits and feasibility of the project. *Second*, provision of the necessary capital in cases where conditions warrant the development. *Third*, performance of the detail engineering work. *Fourth*, building the property in all of its physical aspects. *Fifth*, organization of the working force, including the introduction of a system required to assure the fulfilment of the correct principles of administration. *Sixth*, the actual management of such properties during their routine operation.

Taking the first division cited in connection with industrial-engineering work, namely, an investigation as to the merits of a proposed business, we find that the qualifications required, in part at least, are in no wise different from those which are necessary as a part of the correct system of managing industrial plants; and in fact, in certain fields of activity which have long been open to the consulting engineer, they have been highly perfected and utilized. I refer to the faculty for absolutely thorough study of conditions accomplished through an analysis of all factors involved. It must be evident that the important thing is not the particular nature of the conditions that are to be investigated, but rather the manner in which the investigations are undertaken. This is amply illustrated by the ability of certain men, who thoroughly understand the method of introducing correct principles of management, to perform this work successfully in a diversity of industries in which they could not possibly possess a personal knowledge of all the individual factors involved. This knowledge they can easily secure through others who in many cases are unable to use it to marked advantage.

The consulting engineer who advises correctly in regard to the feasibility of undertaking a given line of industrial work or considering a public-service work, passes judgment upon the merits of a proposed railway, electric-light and power or other property, must conduct his work with all the comprehensive thoroughness that characterizes the work of the efficient " time study expert " who sets tasks in a machine shop. The two problems differ in degree and scope, but in each case the object is to anticipate the result which will follow if certain conditions capable of establishment are fulfilled. In either case, thoroughness in every particular is imperative, for by no other means can the element of faulty judgment be reduced below the danger point.

Only too often the statement is made " after all it is a matter of judgment," when in reality an adequate study would reveal the fact that at least certain results can be positively assured. In the final analysis this entire question of successful management, even in its most subtle aspects, is based upon a full recognition of the fundamental and all-pervading law of cause and effect. In many directions our knowledge of causes is woefully limited, and effects can be accurately foretold only in the very occasional instance when, because of their extreme simplicity, we can grasp the bearing of the elements or causes. The meteorologist knows the result that will follow if certain definite atmospheric conditions prevail. He can predict with very great accuracy the condition that will exist during the ensuing forty-eight hours, and he could predict exactly the weather condition a year hence if he could comprehend all the factors existing and the influences that these would have (all being the resultant of fixed laws) prior to the date in question. It is on this account that in the field of science, which in its full truth is absolute, are found the real elements of management; and this applies quite as much to the human element as to the material, for the acts of men are just as surely the results of cause and effect. Even now scientific study of heredity and environment is resulting in wonderful insight into human actions.

The sales problem into which the human element enters so largely, and which confronts all industrial properties, is beyond the range of exact definition. It is on this account principally that engineers have not been consulted more generally in regard to proposed industrial businesses. Conditions in the public-service field are, however, quite different in this regard, it being possible to anticipate with a very reasonable degree of accuracy the amount of business which should be secured under different conditions. Hence, the practice of engaging consulting engineers to report upon proposed public-service undertakings has become practically universal, and where the work is properly done the same principles are applied as are now being generally recognized as a necessary part of the efficient system of management.

Possibly the greatest opportunity open to the consulting engineer is in connection with the preliminary or investigating work which we have been considering, and it is in this direction that an understanding of the principles of management will be of the most assistance. These principles as applied to industrial-plant operation prohibit the performance of any kind of work whatsoever that has not for its purpose the accomplishment of an absolutely definite end. The individual workers may not be cognizant of this ultimate purpose, but the entire performance of the shop is based upon its accomplishment. The time is not far distant when the consulting engineer will assume just as much responsibility for the ultimate appropriateness of his work as does the manager of the industrial plant. This responsibility he has assumed in certain particulars as, for example, in the design of bridges, and in fact in connection with nearly all machinery which he designs; but I have in mind the broader usefulness of large undertakings considered as a whole. As long as engineers practised individually, this result could not be expected because of the difficulty of coördinating the work of independent specialists, but through present-day engineering organizations it can be attained in connection with both public-service and industrial properties.

The members of such an organization can profit greatly through a study of the methods of management introduced by leading specialists for the routine operation of industrial properties, for they have properly fitted together the various links of the chain and have given it a complete identity which it did not heretofore possess. As I see it, every one who is engaged in active work is performing some function which is or should be a link in this chain. Considered in a comparatively narrow sense, we have the "time study" expert who is fulfilling the dictates of certain principles of the system of management needed within the comparatively limited confines of, let us say, a small machine shop. Considered in a much broader sense, we have the consulting engineer investigating the feasibility of building an extensive public-service property, and we find, if his work is done properly, that he is working in accordance with all the principles that should be recognized by the " time study " expert, and possibly certain other and broader principles as well.

The engineering company, if handling a large amount of business, is confronted with a very difficult managerial situation within its own organization, for in addition to the direction of the experts who are called upon to make the various investigations already referred to, it must maintain a considerable force of engineers, draftsmen, accountants, and clerks who are engaged upon work which cannot be defined, in so far as its performance is concerned, with the nicety that is possible in the manufacturing business. The function of preparing detail plans and specifications is one that has long been established upon a scientific basis in so far as the purely technical work is concerned, and in fact the advocates of the managerial methods with which we are dealing have often pointed to such work as illustrative of the perfection which should be attained in other fields of activity. Hence, in regard to this detail engineering work, the engineering organization will find that an intimate acquaintance with the proper principles of management will be of the most benefit in connection with its actual accomplishment and will not affect materially the character of the finished work.

In many respects we find that the conditions imposed by a large amount of detail engineering work call for almost exactly the same system of management which is suited to manufacturing work. We will assume that an engineering organization is about to undertake the design of a large industrial plant comprising a number of buildings of different types and the installation of a great variety of machinery. Here we find a problem that is much more complex than is usually encountered in the manufacturing plant, and one that is totally different from the problems presented in the designing rooms of industrials. If the work is to be done efficiently and economically (and it must be so done, for it is the main business of the company, not a department to report upon proposed public-service undertakings has become practically universal, and where the work is properly done the same principles are applied as are now being generally recognized as a necessary part of the efficient system of management.

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The need of functional management is just as great within the type of engineering organization which we are considering as in any other business, for the integrity of its performance is dependent upon the superlative ability of its individual members, and this can be attained only through specialization. It is especially important, however, that the organization should not be lacking in that type of administration which makes for control, for work performed by a large number of engineering experts is not easily coördinated. A large drafting organization should be served by one or more men who prepare in advance, in so far as possible, all work that will go to the individual draftsman, which includes the segregation of all reference data; another man with his assistants will see that the work is carried out in accordance with instructions and by expeditious methods, and other men who are specialists in certain comparatively narrow lines of work will keep in touch with its progress, supplementing where necessary the instructions formerly prepared by them, and finally they will check the work in all particulars. Consequently, there is needed the equivalent of the " gang boss," " speed boss," and " inspector " who form a part of the functional organization in plants administered in accordance with the principles with which I am dealing. The clerical force needed in conjunction with the conduct of a large engineering business is also engaged upon functions which are practically identical with the functions performed in an industrial plant. They issue time and instruction cards in accordance with the schedule, receiving them again after the work is finished or at the close of day, make the entries upon the schedules, cost sheets, etc.

It will not be necessary to consider this application of management work at greater length, although I could show not only that in many particulars other than those just mentioned the principles of management are identical with those pertaining to manufacturing companies, but that essentially the same methods for carrying out these principles are applicable.

The relation of the engineering organization to construction work of all kinds is usually one of direction and supervision only, although a number of the larger companies handle the construction work through their own organizations. Companies of the latter type have before them one of the most fruitful fields for the introduction of correct managerial methods. Although exceptionally efficient construction work is being done in many cases, when judged from the basis of averaged past performance, a realization of the possibility of materially raising the standard must be evident to the reader of Mr. Gilbreth's books. Although construction work is in many particulars quite different from most manufacturing work, yet we find that not only do exactly the same principles apply, but in their principal characteristics the systems needed for the fulfilment of these principles are alike. The fact that no two construction jobs are identical and that the work must be performed properly the first time (for a second opportunity cannot be had), and that it is widely scattered geographically, makes particularly necessary a control of all materials, routing and scheduling of work, standardizing of methods of doing work, the prompt securing of accurate returns, and equitable compensation for work done.

The engineering-construction organization is particularly well suited to reap the full advantage of the methods of administration in question, owing to the fact that it has full control of both the engineering and construction work and so can start schedules and other features as soon as the work goes into the drafting room. Of course a complete accomplishment of this result cannot be brought about in a short space of time, even in individual cases, and must to a certain extent be a matter of evolution. A recognition of the integrity of the principles involved is the first step, and then the actual introduction of the required methods must be entrusted to men who have established their positions as being qualified in this regard.

When the relation of the engineer to construction work is one of direction and supervision, a thorough understanding of the principles which underlie scientific management results in the more efficient handling of the construction work, because he will be better able to determine, when letting the contracts, as to the bidders' respective ability to prosecute it properly; and when it is in progress, he will be a judge as to ways and means as well as to the character of the work done. This is a particularly important matter in connection with percentage contracts. It may be said that the only responsibility of the contractor is to complete the work in accordance with the plans and specifications, but if engineers generally become critics of the administrative methods employed, even though in an unofficial capacity, the standard in this regard is bound to improve. I do not mean that engineers should be better able than contractors to prosecute the detail work, but rather that they should be able to determine quite promptly as to whether or not a serious effort is being made to direct the work in accordance with correct principles. As already stated, comparatively little progress has been made in applying scientific management to construction work, and what has just been said has been prompted by the conviction that a proper understanding of the kind of management in question upon the part of consulting engineers will prove to be a material factor in hastening more efficient performance of construction work, through stimulating the interest of those who handle it.

The fourth division of industrial engineering and the fifth division of public-service engineering, referred to above, pertain to the introduction of correct methods for handling the routine work which constitutes the businesses of the respective classes of properties. As this is the particular service in connection with which a great deal more has been accomplished than in the fields of activity to which I have referred, and about which so much has been written, I will not discuss it in this paper. This introduction of these methods constitutes a service which is so complete in itself and so personal in its character that it is not likely to become a part of the work done by large engineering organizations, except possibly in isolated cases. However, I have pointed out that the principles should be understood by the members of such an organization in order that their work may result in at least broad conditions which will be substantially those desired by the capable managerial expert whose service may be subsequently secured.

The management of public-service properties by engineering organizations has become an established department of engineering work and affords exceptionally favorable opportunities for the full utilization of correct managerial methods. It must be evident that this work has been vested in the engineer on account of his ability to deal efficiently with the problems presented. As a matter of fact, while it is conceded that the engineer is needed to look after the maintenance and operation of the physical equipment, the owners of public-service properties have not, in all cases, been as ready to acknowledge that the scope of his work covers their proper administration in the broadest sense. This conclusion applies correctly to the engineer who interprets the word engineering in the narrow technical sense, which was, in fact, the usual interpretation prior to a comparatively recent date. The moment, however, that the engineer acquires an adequate grasp of the subject of management and properly qualifies for the application of the necessary methods, he becomes fit for the entire service.

Of course only a comparatively few engineers are fitted for the conduct of engineering work in the comprehensive conception just defined, but this does not contradict the above statement as to the full scope of engineering service. As a matter of fact, the purpose of the engineering organization is to meet this very obstacle, through combining under one administration a number of engineers possessing the various qualifications needed to cover the entire field. However, the service rendered by the members of such an organization cannot be wholly successful unless they are accorded, on certain classes of work, the fullest coöperation by the men who are active in the client's company.

It is interesting to note that the judgment of engineers whose work for many years has been based in large measure upon highly scientific methods has been more and more sought, until they have reached a position where they are looked to as the final authority upon matters which, until recently, would have been considered as remote from their legitimate field of activity. In fact, scientific management is but management in accordance with true engineering methods; for these now include, and in certain directions have included, the human element as well as the mere materials of construction, and it is acknowledged that we must seek our managers from the same ranks that have supplied the men who have been the builders of the very properties that now need more efficient direction.

"SCIENTIFIC MANAGEMENT" IN BUSINESS

By A. W. SHAW

EDITOR AND PUBLISHER OF *System*

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THE much-discussed "Scientific Management," reduced to simple terms, is a particular form of industrial management that develops the individual worker to the highest state of efficiency and of prosperity and at the same time secures greater prosperity for the factory owner by getting his product made at the lowest possible cost.

Its principles have been slowly but accurately formulated by Frederick W. Taylor, the first investigator in the field of industrial management whose work may rightly be termed scientific.

Literally, with a stop watch, scales, and a tape, Mr. Taylor timed the various routine operations of the workmen in the great steel plants of Pennsylvania, in one of which he was successively laborer, foreman, chief engineer, general manager. He measured distances that men and materials traversed, and gradually evolved the theory that a large percentage of both labor and material was needlessly wasted, — often as high as 60 or 80 per cent in a single department, — through improper supervision and direction. Through changes which he effected he materially reduced the time in which these operations were done. By a comparison of figures he expressed the economies which his methods effected in specific terms of minutes, cents, and ounces. Upon these terms as a basis, he constructed a plan of scientific shop management that he described in a paper which he read before the American Society of Mechanical Engineers at the June meeting of 1903.[1] That date properly marks the beginning of the present movement to establish industrial management as a profession subject to scientific laws.

[Here follows an explanation of the Taylor System as practised at the Tabor Manufacturing Co., Philadelphia, and a suggestion that some of its principles had been applied to sales organizations in other plants.]

[1] Refers to Taylor, *Shop Management*. — ED.

Similar Principles Applied to Salesmanship

The National Cash Register Company, for instance, had reduced its selling methods to the point that it had analyzed, classified, and embodied in text-book form the theory and practice of salesmanship as applied to its particular product — the first, perhaps still the most complete codification of rules that has ever been formulated for the guidance of salesmen. Every detail of the demonstration of the company's product has been analyzed and expressed in the order and even in the phraseology that experience has proved to be the most effective. Every salesman is obliged to memorize this "selling talk," and to conduct a demonstration throughout in exactly the same words and manner as is prescribed for every other salesman; the entire process, in brief, has been standardized.

In another volume have been collected, from the practical experience of its salesmen, every objection that had been made by a prospective customer against the purchase of the product, together with the approved arguments in refutation. These arguments are studied and in many cases memorized by the salesmen.

The same methods have been employed to standardize the work of the sales department as a whole. The salesmen are divided into grades, according to their abilities. As soon as a salesman attains a specified ability as expressed in "points" (a "point" is the standard sales unit, and represents a sale of $25 in value, with additional values for the sale of special grades of goods) he is admitted to the school for salesmen, conducted by experienced instructors. Here he attends courses of lectures, recitations, and selling demonstrations extending over a period of six weeks, at the end of which oral and written examinations determine whether he is qualified for a certificate. Prizes are given for excellence in these courses, and the classes are organized and "graduated" similar to the classes in ordinary educational institutions. At stated intervals these classes are called in to pursue "post-graduate" courses of instruction, as the changes in the policies of the company and in its products demand.

The entire globe is divided into sales territory under district managers and their subordinates; for each district and sub-district a sales " quota " is established each month. A " quota " is the volume of sales (as expressed in points) which, in view of the season, local conditions, and other considerations, may be reasonably expected. Thus a standard of proficiency is established for every man in the selling organization — a " bogie score " that must be equaled to maintain the record and that must be excelled in order to qualify for the numerous bonuses and prizes that are constantly held out as incentives.

So completely has this selling organization been standardized in its details and so successful has it been in maintaining an established ratio of growth, that its methods have been adopted by other organizations that are using them with equal proficiency. And when the United Cigar Stores selects locations for its shops by stationing a representative of the company on the spot for specified periods, to make an actual count of the number of people who pass that spot in the course of the day, and when in another concern an office manager, with a stop watch, times the work of every stenographer and posts each week, as a stimulus to effort, a comparative record that shows the speed, accuracy, and volume of work performed and on this record, as a basis, establishes a scale of wages, both are taking long, long steps toward Scientific Management.

Application to Business Problems in General

For these, broadly, are the steps toward Scientific Management: —

1. To separate from the " line organization " or to add to the line organization a staff officer or " staff organization."

2. To set up tentative standards of performance.

3. To correct these standards by working out scientifically the best methods of performance.

4. To determine the best inducement to the employee to attain these standards.

5. To equip the employee with clear, complete, and exact knowledge of the best way of doing the work.

This is not, perhaps, as Mr. Taylor would designate them, but as they might be taken by a business man who, having studied the literature of Scientific Management, would apply its principles to an individual business problem.

For Mr. Taylor's studies have been of industrial workers. And the exact systems he has devised and installed have been applications of the principles or laws that he has discovered to industrial organization. They should be introduced, in their entirety, in no factory except under the direct supervision of Mr. Taylor or of men trained by him or trained directly under his influence.

But many a false prophet will come to the business men bringing only the shell of Mr. Taylor's methods and not the principles, just as when the first general introduction of business system brought in its trail heterogeneous assortments of cards, filing cabinets, and record sheets that involved endless clerical labor to operate and which in many cases constituted useless red tape. For a period business men mistook the form for the substance; they believed that in the filling and filing of blanks they had "system," and ignored the real system of which these forms were merely the mechanical tools. The result was that this mechanical routine was either stripped of its non-essentials until it became a serviceable implement or was discarded entirely for the old-fashioned inaccurate rule-of-thumb method. A system is not a card or a filing cabinet; it is the right way of doing a thing. Similarly, Mr. Taylor's method of Scientific Management does not consist of forms or charts or of sets of rules and regulations. It is a big policy of establishing after scientific study and research a standard way of performing each industrial operation with the best possible expenditure of material, capital, and labor. The forms and rules are merely the machinery by which the policy is applied.

What is a Full Day's Work?

Back of the Taylor principles and back of his particular method of applying them to actual workshop conditions, is this affirmation of the psychologists, — that all of us, employers and employees, have but a vague conception of what constitutes a full day's work for a first class man.

Many of us confuse overwork with what is really underwork and it is only under a compelling incentive that we discover that like the runner we have a second wind.

And the problem is not merely to ascertain what is a full day's work for the workman but to ascertain what is a full day's work for the works manager, and for the office boy and the office manager, for the salesman and the sales manager, and how to induce the performance of that full day's work.

Therefore, the precise principles Mr. Taylor has formulated for industrial operations have been applied, in most cases perhaps unconsciously, to almost all forms of commercial activity.

Establishing Standards of Sales Costs

Perhaps this is best illustrated by the experience of a Chicago house whose products are sold at retail by a staff of traveling salesmen who come into personal contact with their customers.

The sales manager was additionally compensated over and above a certain salary by a percentage of the value of the sales made under his direction. His major effort, therefore, was directed to the increase in the gross amount of the sales, unconsciously irrespective of the profits to the house. That he eventually used in the conduct of his department methods that were expensive and extravagant in order to secure a large volume of sales was due to a gross but common error in the policy of the concern, — compensation based only on volume of sales. The monthly statement showed such a constantly increasing average of sales expense that finally the management issued an order that every expense requisition of the manager should be approved by an official in the financial department. Friction resulted and with it the diminution of this sales manager's most valuable characteristic, — enthusiasm. The percentage of the sales expense promptly decreased and so did the volume of the sales.

To meet this situation the management with the sales manager and a few executives of the company who were temporarily recalled from the " line " organization and placed on the " staff " for advisory purposes, went into a careful analysis of each phase of the work of that department. Assuming for the time the viewpoint of the outsider, the committee divided each operation into its details and regarded each in its relation to the whole. Gradually it established standards for practically each operation of the department. It placed a tentative standard for the gross annual sales, based on past records and on present conditions. It established a standard percentage for the cost of making these sales. It analyzed the various expenses into their several factors. It prepared from the books of account a printed sheet, ruled and tabulated to record the daily and monthly statements in such form that they would acquaint the sales manager with the expenses that he was incurring, both in percentages and units, and in relation to the sales. It studied the methods of the individual salesmen and sales managers and prepared suggestions and directions as to the best methods to be used by both. It corrected the original tentative standards, and pointed out wasteful methods in the daily work of the salesmen and in the daily work of the sales manager.

Then the management said to that sales manager: —

> Here is a codification of the methods under which our product is to be sold. Here are the exact percentages that we can afford to pay to make these sales. And here is our proposition to you. Your salary will remain as it is. On the gross amount of the sales you make we will pay you a certain percentage. If you can attain in sales that standard which we will set up and can attain the standard at a less percentage of expense than we have designated as a standard percentage, one-half of what you save will be yours to keep. You will approve your own requisitions for expense.

In seven months the sales doubled in volume and the expense had averaged below the predetermined standard and below any past record of performance.

THE TRUE SCIENCE OF BUSINESS

But out of all the reverberant publicity given "Scientific Management" — the term itself has almost become standardized — what is to be gained by the average business man?

For the science of business itself, when carefully formulated, will be, after all, as Dr. Scott says, merely common sense, the wisdom of experience analyzed, formulated, codified, and all in respect to certain data.

But the data are being accumulated now. That is what business men individually and through their organizations, and business publications and educational institutions, notably the Harvard Graduate School of Business Administration, are doing to-day. Analyzing business the world over, picking out details, matters of routine, specific methods of management, individual plans of organization which under certain conditions have produced certain proven results — picking out, in other words, the right way of doing things, or as Mr. Taylor has expressed it, the only right way of doing things — the system.

The principles of this science of business have only just begun to be formulated. But from a study of the principles of "Scientific Management" the business man can get a new business viewpoint — a new mental attitude toward his specific business problems.

That is important. For success or failure in business depends as much upon mental attitude as upon mental aptitude. And the mental attitude that prompts one business man to make a scientific study of his own peculiar requirements and by experiment determine the most effective ways of getting the thing done — whether the task is carrying a pig of iron or selling a carload of canned corn — is the mental attitude that makes for business success.

If production costs have been high, the manager's method of attacking the problem in the past has been simply to try to lower wages or to add machinery. If selling costs have increased, he has tenaciously tried to increase selling prices. And in all of his movements he has usually been guided by accounting that was merely historic — not prophetic; by standards based on past performances — not carefully analyzing possible performances.

But a changed mental attitude suggests a new approach. If costs of production are high the business man will study the equipment that he already has. He will study workmen and ascertain scientifically just what is a full day's work for these workmen and what will help and will induce them to perform this full day's work. When selling expenses rise he will look first to the men who by words of mouth or by written words sell his product. And he will examine the standards against which these men are working and the exact methods that they use.

Result: Lower Prices

The effect upon the purchasing public of the introduction of Scientific Management will in the beginning be negligible. As long as its application is confined to occasional individual businesses, the economies that it will effect will be internal and the profit will be restricted largely to the local management. But as a scientifically managed plant, because of its lower costs of production, can eventually undersell its competitors, the same methods of management will eventually become universal and the economies will be shared by the industry generally and thus become external. The inevitable result will be a lowering of prices to the customer.

Increasing the Workman's Value to Himself

Because of the fact that scientific direction of labor is an increase in the production of the worker as a unit and of the organization as a whole, its principles have at times been opposed by various bodies of workmen who, through a misconception of their real purpose and with the knowledge of the universally recognized defects of the ordinary piece work system, have branded Scientific Management offhand as merely another effort to " speed up " the workmen. In reality the new management aims primarily not to increase the strain on the worker by forcing him into redoubled effort, but to apply his effort to greater advantage. It places at his disposal methods and machinery that have proven, by actual test, to be the most economical of his time and strength. It furnishes him with instructors (known as " functional foremen ") who are more experienced in certain phases of his task than he himself, through whose supervision he is enabled to use these methods and machinery to best advantage. By a system of records, it determines the workmen's special capacities that permit him to be set at the work at which he is most proficient. And by means of a bonus system it provides for the adequate remuneration of the worker not on the basis of effort expended, but upon the more modern basis of effort practically applied and expressed in units of production. As a consequence, the workman's value to himself and to the organization is increased, as rapidly and as highly as his capabilities permit.

A HISTORY OF THE INTRODUCTION OF A SYSTEM OF SHOP MANAGEMENT

By JAMES M. DODGE

CHAIRMAN OF THE LINK-BELT COMPANY, PHILADELPHIA, PA.

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1. After nearly three years' experience introducing into the establishment with which I am connected the system of shop management, identified with the name of Mr. Fred W. Taylor of this Society, I feel that a brief recital of the moving causes which influenced our Company to take up this work would be of interest. I think also it will form a historical recital of the steps and results on broad lines.

2. The works consist of a machine shop, with its usual accompaniment of storeroom, tool-room, pattern shop and power plant, together with the required shop, offices, accounting departments, drawing-room and engineering forces and the selling organization. There is also quite an extensive department devoted to construction and erection in iron and steel. There is no duplicate work done and no package article made or sold as would be the case in large duplicated lots.

3. At the time we first considered the Taylor System, we prided ourselves on having a thoroughly equipped shop, operated by the best methods known to us as respects general management, general accounting and shop accounting. We thought we were decidedly in advance of others in our particular line of business and even of other machine shops. While we felt that we were not intensely progressive, we were also in a satisfied mood, feeling that it would be rather presumptuous for any one to suggest that our method and general way of doing things could be improved.

4. It was in this frame of mind that we received word of the surprising work done at the shop of the Bethlehem Steel Company with a grade of tool steel to which the names of Taylor-White

were attached. I myself made the trip personally to the shop where it was in use and saw tools of this material ripping heavy nickel steel faster than we were in the habit of turning off brass. I also saw under the shadow of a screen over the point of the cutting tool that it cut with a dull red heat. I found on computation it was turning off a good big chip at a rate of 140 feet a minute and after twenty minutes there was no let up.

It was something of a shock to me to discover that the wonderfully valuable mechanical training I had had and my twenty years of experience would have to be regarded as obsolete from that moment onward.

5. An inspection of my own shop the following day made it apparent that we were hopelessly behind and that it would be necessary for us to rearrange our whole establishment if we were to keep up with the standards that my previous day's experience had forced upon me. This carried with it the sickening feeling that I was going to spend a fortune, was to reduce dividends for several years, was to make an expenditure of a large amount which would give no result in anything to be properly inventoried as an asset, and one-hundred-and-one other financial and mechanical obstacles. To convince my own tool-maker, who like so many other tool-makers was the best in the country, we took down some of his best achievements in tool-making to the Bethlehem shops and the instant failure of our samples alongside of the Taylor-White product resulted in our negotiating a few days later for a shop right.

6. Considerable time was spent in getting tools of the right sort for working on cast iron, with the result that we had one lathe and a few tools to fit it which would do from three to four times as much work on cast iron as we had ever been able to do before. This, however, was only the beginning. When we went further the old machine tools had to be either discarded or new ones of special design substituted, or the old tools rebuilt. Electric driving became necessary and finally our machine shop, which had been run most successfully with a 50 horse-power engine, was absorbing over 150 horse-power and calling for more.

Then it became quite evident that the piece rate would have to be revised. For instance, if 50 pieces could be made per day on a tool, an error in rate either for or against us would be multiplied by fifty, whereas if the same tool could turn out 200 pieces a day our error in rate fixing would be multiplied by 200.

Mr. Taylor's answer to our question was that a scientific time study would be necessary. We were loth to accept this because we were following what we regarded as a much quicker and better method which was that of "guess," and we had in our business a number of men who could guess perfectly. Time soon began to show that these wonderful but unscientific guessers were far from infallible, and the guessing was decidedly inaccurate. We were shocked that our perfectly appointed and well-managed tool-room was becoming nervously prostrated and needed "jacking up."

What looks like a simply jacking up process took eighteen months of hard work, but when we were through we were more than satisfied with the expenditure. Increased output reflected glaringly upon the heretofore considered perfect system of storekeeping and accounting. The receiving-room had to be reorganized to fit the storeroom. The routing of material through the shop which had been very satisfactory and simple — we were having from six to twenty men remembering hundreds of details — came also to show signs of mental decay. The instruction of our men, the strain of having their lathes speeded, the changes in personnel were all consequences of our first step.

7. The final result was that we called in the man who had been instrumental in getting us into our difficulties and asked him to get us out. The more we worked under the able direction of Mr. Taylor and the assistance of his Mr. Carl G. Barth, also a member of the Society, the more we were impressed with the fact that Mr. Taylor in formulating his system had taken good points of management from various sources and had skilfully combined them in a harmonized whole. It took over two years for our organization to surrender fully, and so change our mental attitude that we became really receptive. I mean by this that I found no difficulty at all in having the heads of various depart-

ments agree that the introduction of the Taylor System would be most desirable, but in every case it was for everybody else in the establishment but entirely unnecessary for him.

8. I might illustrate a cardinal feature of Mr. Taylor's System by asking you to consider the policy of operating a Fall River steamer with a crew of 200 men, all of whom were in such authority that they were entitled to make suggestions, raise objections and insist on the whole group proceeding with great caution. Obviously the vessel would be in the greatest peril all the time. The one method is to have this entire crew of 200 all functionalized, each man doing his own work under general and specific directions, with a trained pilot steering the boat. If the pilot, for his own glory, insisted upon being illumined so that every one could see him, his usefulness would immediately become impaired. I am fully convinced that the successful perpetuation of a business becomes the more certain the further away we get from the old military idea of having all the brains owned and controlled by one man. We have all seen prosperous concerns come to grief because the person who had the brains and ability to build it up had not been broad-minded enough to see that brains and ability were left behind when he died to conduct the business successfully. In an epigram: "Under the old military system every one was supposed to help the boss. Under the Taylor System the boss is obliged to help and assist the others who are under him." Under this each individual is unconsciously training his successor and working himself out of a job! This "working ourselves out of a job" by the ability and training of a successor makes it possible to promote any one of the works without a loss of efficiency to the whole. The boss is promoted just as much as any one else, and his promotion comes to him in the form of perfected organization, releasing him from detail and giving him a greater opportunity to devote his brains and his experience to the development and extension of his business.

9. I have endeavored to make plain that my individual mental attitude and that of my associates was and is in no way unusual. The whole question resolves itself to this. The high-speed steel called for and made necessary a better system than existed in its

AN OBJECT LESSON IN EFFICIENCY

By WILFRED LEWIS

PRESIDENT, THE TABOR MFG. CO., PHILADELPHIA, PA.

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PUBLIC attention has recently been drawn very pointedly to the subject of scientific management, and the Tabor Manufacturing Company, of which the writer is president, has frequently been cited as an illustation of what has already been accomplished along the lines laid down by Frederick W. Taylor.

Prior to my connection with the Tabor Manufacturing Company, in 1900, the whole of my active business life had been devoted to the cause of efficiency in machines, and I believe with some measure of success, but I had yet to learn the value of good management in the development of men, and the greater importance in business life of efficiency in men as against efficiency in machines.

As then organized and conducted in 1900, the business was rather commercial in character. The machines were built on contract to our designs and the activity of the company was directed chiefly toward their sale and demonstration. I soon found a number of details in which the designs could be improved, but as a promoter of sales, I was entirely out of my element. I proposed, therefore, that we should have a shop of our own, and begin to realize whatever profit there might be in manufacturing.

At this time I was advised by my well-wishers to maintain an open shop and keep down the number of clerks or non-producers. Success, I was told, depended upon the ratio of producers to non-producers in any well managed concern. Draftsmen were recognized as a necessary evil, the fewer of whom the better, and one good superintendent to lay out the work and keep it moving through the shop was considered quite enough. In fact, to the casual observer, we had hardly enough work to keep a good man busy and we did not appreciate the need of better shop management until our growing business began to show increasing losses. Before we were aware of any dissatisfaction, also, and within a year of the opening of our shop, we were surprised by a general strike for higher wages and shorter hours. Our unguardedness or lack of management had encouraged our men to combine against us and make unreasonable demands. We were then paying them more than they earned and they insisted upon having still more, which simply meant ruin to the company in a shorter time. Our strike was compromised by the concession of shorter hours at the same pay, the men agreeing to turn out the same amount of work per day. There was no difficulty about their doing this, and for a time, I believe they kept their promise, but a day's work was then with us, as it is now with nearly the whole world of industry, a very variable and indefinite result for a given expenditure of time or money. We had no standard by which a proper day's work could be fixed except the very shaky and misleading one of the best that had been done before, and having, as we were now well aware, an organized resistance against any increase in output or efficiency to meet, the outlook for the company was not encouraging.

At the same time we knew that machines had been built by others for less than they were costing us, and we felt confident that a way could be found out of our difficulties. But we were obliged to sell stock and borrow money for several years, until it seemed unreasonable to expect any further financial aid. Fortunately my good friend, Taylor, who was then writing his remarkable essay on "Shop Management," came again to our assistance and offered to loan us more money if we would agree to put in his system of management. We were only too glad to do this, without having any conception of what it really was or would finally mean to us. Accordingly, the money was advanced and in due time the installation of the Taylor system was begun.

Advance sheets from "Shop Management," which was read before the American Society of Mechanical Engineers in 1903, were sent to me as they were written and Mr. Taylor himself gave some personal attention to the introduction of his system.

The enormous amount of detail involved required, however, the constant attention of a trained expert and we were fortunate at the outset in securing the services of Mr. Barth, one of Mr. Taylor's assistants in the reorganization of the Bethlehem Steel Company. We had nothing in the nature of system that fitted in or was worth preserving, and Mr. Barth was obliged in the first place to lay the foundation for the structure he proposed to rear. This meant a lot of preparatory work for which there was no immediate use and from which no return could be expected until other features were introduced.

In the meantime, the business had to go on, while those engaged in running it were subjected to more or less inconvenience by the changes proposed, and these led to a good deal of irritation and dissatisfaction in certain quarters. In fact, it was not long before a revolt began to be felt which was not confined entirely to the shop. At this crisis Mr. Taylor recognized the futility of attempting to reorganize a house divided against itself and insisted upon his right to direct the introduction of his system according to agreement without obstruction or interference in the shape of adverse criticism, and for a time the good work went on without active opposition, perhaps, but certainly without the hearty good will most needed from within. Mr. Barth was obliged, as he proceeded in his work, to call for more and more assistance, and as new men were added to our planning department, the cost of the new system began to draw so heavily upon our resources that for a year or two we seemed to be actually losing ground, and we certainly would have been obliged to suspend but for the grit and determination of Mr. Taylor, who had the courage of his convictions and carried us through the storm which culminated in the resignation and withdrawal of the opposing forces.

From this time forward conditions began to improve, and the work began to bear fruit. It was not long before we ceased to lose money, broke even and began to gain. A better spirit prevailed, better wages were earned, and production increased so rapidly that I was lost in astonishment at the potency of the engine gratuitously placed in our hands. We had in effect been installing at great expense a new and wonderful means for increasing the efficiency of labor, in the benefits of which the workman himself shared, and we have to-day an organization second I believe to none in its loyalty, efficiency and steadfastness of purpose. Its loyalty was tested a year ago[1] at the time of the general strike when the streets of Philadelphia were filled with thousands of idle men bent upon inducing others to join them. Out of the 150 then employed, but one man failed to resist the pressure, and he was paid off without regret as one of our least efficient workers.

I have given the above brief history of my experience to emphasize the adverse conditions under which the Taylor system was installed and carried on to a successful conclusion. I do not believe so much opposition will ever be encountered by others, because carping criticism has been subdued, if not yet silenced, and successful methods are sure to be emulated; but more or less resistance is always to be anticipated, because any change, however slight, in management may be taken as a reflection upon previous methods of reaching the desired end, and therefore as personal to the advocate of discarded ways and means.

The suppression of personal pride and prejudice, with the disposition to seize and adopt the best ideas to be found anywhere, has been a great help to the scientific habit of thought under which the Taylor system of scientific management has been built up and will continue to grow. Differences of opinion may arise and different conclusions may be drawn from the same evidence, but a body of fundamental principles has already been established by Mr. Taylor which may safely be taken as the nucleus for a new science of management. As in any other science these fundamental principles must be subjected to rigid analysis and demonstrated in a practical way by successful performances, seeking always "truth for authority and not authority for truth."

The advice given me eleven years ago about keeping an open shop and weeding out the non-producers was good orthodox

[1] This refers to the great street railway strike and the many sympathetic strikes that accompanied it. — Ed.

business gospel at that time, and it would no doubt still be endorsed to-day by 95 per cent of the manufacturers in this country, who would also subscribe to the principle of one supreme authority delegated and subdivided among subordinates on the military plan, as the only practical type of management for any business.

But who knows, when he has an open shop, to what extent it may be filled by conspirators ready to take advantage of the first opportunity to make unreasonable demands, and how can loyalty be fostered and encouraged throughout all departments of a diversified business? How comes it also that a large increase in the force of non-producers can be made to effect such an enormous increase in output?

In 1910 the Tabor Manufacturing Company turned out two and one-half times as much value in finished product as it ever did under the old *régime* with the same force. Formerly for every ten men engaged as producers, or "chip-makers," as Mr. J. M. Dodge defines them, we had not more than one man connected with the shop as a non-producer. Now we have fewer men at machines with three times as many non-producers turning out practically three times as much work, because prices are lower to-day than they were five or six years ago and two and one-half times the value means about three times the product.

To explain in detail these anomalous results would carry me far beyond the limits of this paper and call for the elucidation of a system which had better be studied at first hand in Mr. Taylor's *Principles of Scientific Management*. At the same time the type of management under which we are working should be seen in operation to be fully appreciated, and I must confess that in the beginning, eight years ago, I gathered very little about it from my perusal of the advance sheets on "Shop Management." The fact is that the system is so engrossing and calls for so much undivided attention that it is almost futile for any one actively engaged in meeting customers, providing for their wants and collecting accounts, to undertake its installation single-handed. The reorganization should therefore be left to an expert who is not hampered by the necessity of running the business.

It is not an easy matter to start any innovation in an open shop full of union men, and, as might be anticipated, the appearance of a man with a stop watch and tally sheet was at first very irritating and strenuously opposed by the workmen. So also was the suggestion of a bonus for the successful performance of an allotted task. But the kickers were gradually converted or discouraged, better discipline was established and a few of the men were soon earning 30 per cent more wages than they could command elsewhere.

In the beginning the men were suspicious and disinclined to believe that a good performance was not to be the signal for a cut in price, but they have since learned by experience that prices are fixed by the management upon definite knowledge of all the time elements involved in any piece of work and that the time allowed will not be changed so long as the method employed remains the same. In this way the management demonstrates its loyalty to the workmen and they in turn are glad of an opportunity to demonstrate their loyalty to the management, as they did last year.

We pay better wages for fuller and better results performed in a definite way, and yet there is no driving in the ordinary sense of the word. The tasks assigned to the workmen are easily within their ability to perform and when new work is given out, as occasionally happens, at day rates, before the time on the job has been set, nobody wants to take it because there is no bonus attached for its quick and accurate performance.

But our wonderful increase in production is not due entirely to rapidity of performance, for in some instances very little gain in that direction has been made. A great deal is due to the functional foreman whose duty it is to prepare and guide the way of every piece of work going through the shop. The old notion that a man cannot serve two masters or take orders from more than one superior is denied by the new philosophy which makes it possible for the workman to have as many bosses as there are functions to be performed. There is no conflict of authority unless the functions overlap, and even there such conflict as may arise is salutary and to the interest of the company. A gang boss, for instance, covers one class of machines or work, and it 's his business to see that every man is provided with at least one new job with all the tools and fixtures ready for its immediate performance as soon as the job upon which he is engaged has been completed. He also gives the necessary instructions about setting the work, explains the drawings and teaches the workman how to set his work when necessary. This man has nothing to do with the running of machines and does not interfere at all with the speed boss who also has supervision in his function over the same men as the gang boss and sees that each machine is run at its proper speed with feed and cut as per written instructions. He also teaches the workman and gives him such practical assistance as may be needed. An inspector also helps the same set of men and sees that the work done is of the right quality and that the first piece made is up to the standard in all dimensions, fit and finish. He also makes further inspection from time to time to see that the standard is maintained. An over-zealous speed boss in his desire for a large output may impair the quality of the work done by exceeding the speed limit, and there is therefore the possibility of a conflict between the speed boss and the inspector, but the inspector's requirements must be fulfilled and such a conflict cannot fail to be salutary, because rapidity of production when accompanied by inferior results is never to be desired, and in almost all cases some method is found by which high speed can be maintained and the best quality preserved. It rarely happens that the superintendent or manager is called upon to adjust a difficulty between the two functional foremen.

In assembling the various parts required to make a complete machine the stockkeeper sees that all the parts for a group of machines are in hand ready to go together before work is begun upon any one of them and the whole group is finished at the same time.

To avoid delays incident to materials which should be ordered in advance, the storeroom must carry a sufficient amount of stock to cover the time required for replacements, and this is cared for by a storekeeper and his clerical assistants in an automatic way. Formerly it was necessary for the superintendent to bear in mind or to look ahead to see what was wanted in advance, but with many thousand parts going through the shop at once, important details, sometimes few and sometimes many, were invariably overlooked, which meant delay and disappointment to the customer and very often the cancellation of orders. Now a balance of stores is kept in the planning department by which new orders are placed as soon as the stock on hand falls below a certain established minimum kept plainly in view against every detail. This minimum may vary as conditions change and it is fixed by the discretion of the manager of the planning department in consultation with the sales department.

In the planning department, which is to the shop what the drawing room has been for many years to the superintendent, every new machine is charted to show the progress of the work through the shop and every piece is provided with an instruction card for its proper manipulation, showing the machine upon which it is to be made, the tools and fixtures required, the feeds and speeds to be used, the sequence of operations and the time allowed in detail for each and every elementary movement. As these operations are performed they are checked off in a route file from which can be seen at any time the exact condition of the work and the time remaining for its completion.

An order-of-work-clerk directs the progress of the orders to be filled in accordance with a schedule prepared by the manager in consultation with the sales department and he has before him in miniature a view of the whole shop, showing every machine or vise, the work being done on each, the work ready to be done and the work ahead in the shop, but which has not yet arrived at the machine. This is a large board or wall plate, which shows also what machines are manned and where a man can be conveniently shifted when there is no work ahead at his particular machine. By this means all of the work in the shop is kept moving in proper balance at a normal rate of speed, men are taken on or laid off as the exigencies of business may require, and no loss is sustained by the usual tendency of workmen to relax when orders are falling off and work ahead is hard to find. At such times we are, of course, obliged to curtail production, and the situation being apparent to all, no complaint is made against a reduction in time, which we always prefer to a loss of well-trained men.

A well-equipped tool room in charge of a competent man is a *sine qua non* in any machine shop, and here also one of our greatest improvements has been made.[1] Formerly each workman was inclined to accumulate his own assortment of tools and fixtures which were stowed away in dark corners and kept in disorder and confusion. Now everything comes in perfect order (and the best of its kind) from the tool room as required and goes back again when the job for which it was taken out is finished. Tools are ground to standard forms and not to suit the whims of individual workmen and the tool room is responsible for the condition of all tools sent out.

The drawing room is perhaps of all departments less affected by the new order of things than any other, and yet there is an indirect effect due to the atmosphere of activity which pervades the whole plant. Here the work is by its very nature more or less original and, of course, no time can be set for the completion of that which is not definitely known, and which grows into shape by a process of trial and error, until something satisfactory is attained. Designing is not therefore amenable to time study, and, depending largely as it does upon inspiration, there is no superior intelligence to direct its progress. It is in the nature of original research which flourishes and bears its best fruit under adverse criticism. A good designer is like a good composer, his work is creative and full of harmonies, and being an artist in his line he cannot be held to a time schedule. In original work, the incentive, therefore, must come from within rather than from without, and this is generally inborn with the ability to create. Copyists, on the other hand, who always need direction, might be brought under the domination of time study and in many clerical operations this has been done, but we have not yet attempted to fix tasks in tracing or bookkeeping, and we do not

[1] See R. T. Kent's "The Tool Room under Scientific Management," p. 434.— Ed.

pretend to say that our development is by any means complete. We have progressed, however, to a point which makes further progress comparatively easy, and in the face of stubborn opposition we have firmly established a successful business upon the principles of scientific management as laid down by Mr. Taylor. This means increased production and higher wages at a lower cost, and contains the key to the solution of the labor problem. Labor is made to share in the increased production realized, and the reward of labor is made to depend upon the individual effort put forth in production. The Taylor system makes more room on top and gives a better chance to rise. Men thus schooled in efficiency are qualified for better service and learn to measure more accurately the value of time.

The scientific habit of thought, as applied by Mr. Taylor to the production of high-speed steel, has resulted in speeding up machine shops about three to one, and I think it is not unreasonable to expect that the same habit of thought as applied by him to the every-day hand work of men will eventually result in doubling the average output of labor with comparatively little increase in the physical effort required. The margin for improvement varies, however, so greatly in different trades and countries that an accurate estimate cannot well be made.

ON THE ART OF CUTTING METALS

By FREDERICK W. TAYLOR

INTRODUCTION BY THE AUTHOR

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Presented at the New York Meeting (December, 1906) of The American Society of Mechanical Engineers, being the President's Annual Address.

The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop our system of management, the central idea of which is:

To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of the work.

To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance.

There are three questions which must be answered each day in every machine shop by every machinist who is running a metal-cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

(*a*) What Tool shall I use ?

(*b*) What Cutting Speed shall I use ?

(*c*) What Feed shall I use ?

Our investigations, which were started 26 years ago with the definite purpose of finding the true answer to these questions under all the varying conditions of machine shop practice have been carried on up to the present time with this as the main object still in view.

The writer will confine himself almost exclusively to an attempted solution of this problem as it affects " roughing work "; *i. e.*, the preparation of the forgings or casting for the final finishing cut, which is taken only in those cases where great accuracy or high finish ng on piece work in maishing cuts will not be dealt with. Our prircellaneous forgings, o describe the fundamental laws and principles pieces per day e us to do "roughing work" in the shortest time appointe ne cuts are light or heavy, whether the work is rigid or elastic, and whether the machine tools are light and of small driving power or heavy and rigid with ample driving power.

In other words, our problem is to take the work and machines as we find them in a machine shop, and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes, and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these slide rules to tell each workman how to do each piece of work in the quickest time.

It is to be distinctly understood that this is not a vague, Utopian result, to be hoped for in the future, but that it is an accomplished fact, and has been the daily practice in our machine shops for several years; and that the three great questions, as to shape of tools, speed, and feed, above referred to, are daily answered for all of the men in each shop far better by our one trained mechanic with the aid of his slide rule than they were formerly by the many machinists, each one of whom ran his own machine, etc., to suit his foreman or himself.

It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for ten years by a first class machinist having exceptional knowledge of and experience with his machine, and who has been using his best judgment. Yet, our observation shows that, on the average, this understates the fact.

To make the reason for this more clear it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of the twelve elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, expert or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these twelve variables and measure their joint effect upon the problem.

These twelve elements or variables are as follows:

(*a*) the quality of the metal which is to be cut;
(*b*) the diameter of the work;
(*c*) the depth of the cut;
(*d*) the thickness of the shaving;
(*e*) the elasticity of the work and of the tool;
(*f*) the shape or contour of the cutting edge of the tool, together with its clearance and lip angles;
(*g*) the chemical composition of the steel from which the tool is made, and the heat treatment of the tool;
(*h*) whether a copious stream of water, or other cooling medium, is used on the tool;
(*j*) the duration of the cut; *i. e.*, the time which a tool must last under pressure of the shaving without being reground;
(*k*) the pressure of the chip or shaving upon the tool;
(*l*) the changes of speed and feed possible in the lathe;
(*m*) the pulling and feeding power of the lathe.

Broadly speaking, the problem of studying the effect of each of the above variables upon the cutting speed and of making this study practically useful, may be divided into four sections as follows:

(*a*) The determination by a series of experiments of the important facts or laws connected with the art of cutting metals.

(*b*) The finding of mathematical expressions for these laws which are so simple as to be suited to daily use.

(*c*) The investigation of the limitations and possibilities of metal cutting machines.

(*d*) The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other, the possibilities and limitations of the particular lathe or planer, etc., to which it applies and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best.

In the fall of 1880, the machinists in the small machine shop of the Midvale Steel Company, Philadelphia, most of whom were working on piece work in machining locomotive tires, car axles, and miscellaneous forgings, had combined to do only a certain number of pieces per day on each type of work. The writer, who was the newly appointed foreman of the shop, realized that it was possible for the men to do in all cases much more work per day than they were accomplishing. He found, however, that his efforts to get the men to increase their output were blocked by the fact that his knowledge of just what combination of depth of cut, feed and cutting speed would in each case do the work in the shortest time was much less accurate than that of the machinists who were combined against him. His conviction that the men were not doing half as much as they should do, however, was so strong that he obtained the permission of the management to make a series of experiments to investigate the laws of cutting metals with a view to obtaining a knowledge at least equal to that of the combined machinists who were under him. He expected that these experiments would last not longer than six months.

With the exception of a few comparatively short periods, however, these experiments have continued until the present time, through a term of about 26 years.

The writer wishes to call attention to the fact that in these first experiments he was far more fortunate than almost all of the experimenters who have investigated the subject since then, in having at his disposal a comparatively large mass of uniform metal to work upon, and a comparatively large and powerful machine to work with, a 66 inch diameter boring mill and large locomotive tires made of hard tire steel of uniform quality having been used. He was also especially fortunate in having over him as president of the company, Mr. William Sellers, who, as is well known, was one of the most patient and broad-minded experimenters of his day. Mr. Sellers, in spite of the protests which were made against the continuation of this work, allowed the experiments to proceed; even, at first, at a very considerable inconvenience and loss to the shop. The extent of this inconvenience will be appreciated when it is understood that we were using a 66 inch diameter vertical boring mill, belt-driven by the usual cone pulleys, and that in order to regulate the exact cutting speed of the tool it was necessary to slow down the speed of the engine that drove all of the shafting in the shop; a special adjustable engine governor having been bought for this purpose. For over two years the whole shop was inconvenienced in this way, by having the speed of its main line of shafting greatly varied, not only from day to day but from hour to hour. Before the two years had elapsed, however, the writer had obtained such valuable and unexpected results from the experiments as to much more than justify all of the annoyance and expenditure, and soon after that he readily obtained permission to employ a young technical graduate to devote his whole time to the continuation of this work.

Mr. G. M. Sinclair, a graduate of Stevens Institute of Technology, devoted his entire time to this work from 1884 to 1887, when he left the employ of the company.

Mr. H. L. Gantt, also a graduate of Stevens Institute succeeded Mr. Sinclair in July, 1887, and has been interested with us in carrying on these experiments throughout their whole period.

In 1898 Mr. Maunsel White, of Bethlehem, another graduate of Stevens Institute, joined us and has been actively interested in our work up to this time.

Mr. Carl G. Barth, a graduate of The Technical School of Horten, Norway, joined us in 1899, and is still actively working on our investigations.

During these years we have consulted so freely together in all matters relating to these experiments that with few exceptions hardly a step has been taken which can be said to have originated with any one man. Therefore, whatever credit or blame may come to this work should be impartially divided among us. In writing this paper, then, no effort will be made to discriminate, as to the results which have been obtained in our investigations, between the work of one man and another.

Mr. White is undoubtedly a much more accomplished metallurgist than any of the rest of us; Mr. Gantt is a better all-round manager, and the writer of this paper has perhaps the faculty of holding on tighter with his teeth than any of the others. It should be said, however, that Mr. Barth, who is a very much better mathematician than any of the rest of us, has devoted a large part of his time during the last years of these experiments to carrying on the mathematical work along the lines laid out, and that without his special ability and untiring energy our progress would have been much slower, indeed it is doubtful whether we should have ever reached the present solution of the problem without his aid.

In addition to the five men who have mainly directed and carried on this work, the writer wishes to acknowledge the most loyal and efficient aid and coöperation of many others who have assisted in the actual running of the machines and in recording or tabulating the data. Among these, he would particularly mention Mr. Dwight V. Merrick, Mr. D. C. Fenner, Mr. James Kellogg, Mr. Sidney Newbold, Mr. Joseph Welden, Mr. N. W. Wickersham, Mr. Edward Kneisley, and Mr. Leonard G. Backstrom.

Our experiments were continued in the works of the Midvale Steel Company until 1889, when the writer left their employ. Since then, these investigations have been carried on in various shops and at the expense of different companies. Among these, we would especially acknowledge our indebtedness to the Cramp's Shipbuilding Company, Messrs. Wm. Sellers & Co., the Link-Belt Engineering Company, Messrs. Dodge & Day, and, more than all, to the Bethlehem Steel Company.

In carrying on this work more than ten machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between thirty and fifty thousand recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 pounds of steel and iron. More than sixteen thousand experiments were recorded in the Bethlehem Steel Company. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

Throughout the whole 26 years we have succeeded in keeping almost all of these laws secret, and in fact since 1889 this has been our means of obtaining the money needed to carry on the work. We have never sold any information connected with this art for cash, but we have given to one company after another all of the data and conclusions arrived at through our experiments in consideration for the opportunity of still further continuing our work. In one shop after another machines have been fitted up for our use, workmen furnished us to run them, and especially prepared tools, forgings and castings supplied in exchange for the data which we had obtained to date; and we have the best indication that they received full value for the money spent from the fact that the same company fitted up for us at intervals of several years three sets of apparatus, the additional knowledge obtained each time evidently warranting them in making the added outlay.

During this period all of the companies who were given this information, and all of the men who worked upon the experiments, were bound by promises to the writer not to give any of this information away nor to allow it to be published. Most of these promises were verbal; and in this day when there is so much talk about dishonesty and graft in connection with some of our corporations and prominent business men, it is a notable fact that through a period of 26 years it has not come to our knowledge that any one of the many men or companies connected with this work has broken a promise. The writer has his doubts whether any other country can produce a parallel record of such widespread good faith among its engineers and mechanics.

It seems to us that the time has now come for the engineering fraternity to have the results of our work, in spite of the fact that this will cut off our former means of financing the experiments. However, we are in hopes that the money required to complete this work may be obtained from some other source.

The writer has no doubt that many of the discoveries and conclusions which mark the progress of this work have been and are well known to other engineers, and we do not record them with any certainty that we were the first to discover or formulate them, but merely to indicate some of the landmarks in the development of our own experiments, which to us were new and of value. The following is a record of some of our more important steps:

(*a*) In 1881, the discovery that a round-nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond-pointed tool.

(*b*) In 1881, the demonstration that, broadly speaking, the use of coarse feeds accompanied by their necessarily slow cutting speeds would do more work than fine feeds with their accompanying high speeds.

(*c*) In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40 per cent. In 1884, a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part; each machine being set in a wrought iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well from which it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time, so far as the writer knows, the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884 no other shop in this country was similarly fitted up until that of the Bethlehem Steel Company in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Company.

(*d*) In 1883, the completion of a set of experiments with round nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

(*e*) In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

(*f*) In 1883, the development of formulae which gave mathematical expression to the two broad laws above referred to. Fortunately these formulae were of the type capable of logarithmic expression and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in making our slide rules, and solved the whole problem in 1901.

(*g*) In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts of varying depths and thickness of shaving.

(*h*) In 1883, the starting of a set of experiments on belting described in a paper published in *Transactions*, Vol. 15 (1894).

(*j*) In 1883, the measurement of the power required to feed a round-nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that a very dull tool required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel cutting machines purchased since that time by the Midvale Steel Company have been supplied with feeding power equal to their driving power and very greatly in excess of that used on standard machine tools.

(*k*) In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a tool room for storing and issuing tools ready ground to the men.

(*l*) From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Company, by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

(*m*) In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad-nosed cutting tools which enabled us to run with a coarse feed at as high a speed as had been before attained with round-nosed tools when using a fine feed, thus substituting, for a considerable portion of the work, coarse feeds and high speeds for our old maxim of coarse feeds and slow speeds.

(*n*) In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals, the gain made by the use of self-hardening tools over tempered tools in cutting soft cast iron being almost 90 per cent, whereas the gain in cutting hard steels or hard cast iron was only about 45 per cent. Up to this time, the use of Mushet and other self-hardening tools had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all "roughing work" throughout the machine shop.

(*p*) In 1894 and 1895, the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a gain in cutting speed of self-hardening tools of about 33 per cent. Up to this time the makers of self-hardening steel had warned users never to use water on the tools.

(*q*) From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools; namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

(*r*) In 1899–1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid everyday use in the shop of all the laws and formulae deduced from our experiments.

(*s*) In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from cast iron by the tool would permit an increase in cutting speed, and therefore, in the amount of work done, of 16 per cent.

(*t*) In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

While many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rules; *i. e.*, the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object, for which in 1880 the experiments were started; *i. e.*, that of taking the control of the machine shop out of the hands of the many workmen, and placing it completely in the hands of the management, thus superseding " rule of thumb " by scientific control.

By far the most difficult and illusive portion of this work has been the mathematical side: first, finding simple formulae which expressed with approximate accuracy the effect of each of the numerous variables upon the cutting speed; and, second, finding a rapid method of using these formulae in the solution of the daily machine shop problems. Several times during the progress of this mathematical work, the writer, feeling himself completely baffled, has asked the expert assistance of some of the best mathematicians in the country. They all smiled when told that we expected to solve mathematically a problem containing *twelve variables*, and in each case, after keeping the formulae before them for a longer or shorter time, returned the problem to the writer with the statement that it belonged distinctly in the realm of "rule of thumb" or empiricism, and could be solved only by the slow method of trial and error.

In the investigation of an art such as that of cutting metals, and about which at the time our work was started there was so little scientific knowledge, two types of experiments are possible.

First, the thoroughly scientific type, in which, after an analysis of all the variable elements which affect the final result, an attempt is made to hold all of the elements constant and uniform, except the one variable which is under investigation, and this one is systematically changed and its effect upon the problem carefully noted.

It is to this type that our experiments belong, thanks mainly to the fact that Mr. William Sellers (one of the most scientific experimenters of his day) was president of the Midvale Steel Company when the writer started his work.

Second, the type of experiments in which the effect of two or more variables upon the problem is investigated at the same time and in the same experiment.

This method is of course much quicker than the thoroughly scientific type, and it is largely for this reason, in the opinion of the writer, that almost all of the other experimenters in this field have chosen it. Several of the experiments of this type have proved most valuable and developed much useful information, and it is with hesitancy that the writer criticises the work of any of these experimenters, since he appreciates most keenly the difficulties under which they worked, and is grateful for the information contributed by them to the art. After much consideration, however, he has decided to point out what he believes to be a few errors made by these experimenters, with the same object which he has in indicating our own false steps: namely, that of warning future investigators against similar errors.

Almost the whole course of our experiments is marked by imperfections in our methods, which, as we have realized them, have led us to go again more carefully over the ground previously traveled. These errors may be divided into three principal classes:

(*a*) The adoption of wrong or inadequate standards for measuring the effect of each of the variables upon the cutting speed.

(*b*) Failure on our part from various causes to hold all of the variables constant except the one which was being systematically changed in order to study the effect of these changes upon the cutting speed.

(*c*) The omission either through oversight or carelessness on our part of some one of the precautions which should be taken to insure accuracy, or failure to record some of the phenomena considered unimportant at the time, but which afterward proved to be essential to a complete understanding of the facts.

In the second portion of this paper will be given in detail a statement of the appliances, methods and principles which we believe to be necessary to use in order to obtain reliable results. For the purpose of a more general discussion of the subject, however, it seems important to anticipate this portion of the paper by describing in detail the standard which we have finally adopted as a true criterion for determining the effect of each of the variables upon the cutting speed.

The effect of each variable upon the problem is best determined by finding the exact rate of cutting speed (say, in feet per minute) which shall cause the tool to be completely ruined after having been run for 20 minutes under uniform conditions.

For example, if we wish to investigate the effect which a change in the thickness of the feed has upon the cutting speed, it is necessary to make a number of tools which are in all respects uniform, as to the exact shape of their cutting edge, their clearance and lip angles, their chemical composition and their heat treatment. These tools must then be run one after another, each for a period of 20 minutes, throughout which time the cutting speed is maintained exactly uniform. Each tool should be run at a little faster cutting speed than its predecessor, until that cutting speed has been found which will cause the tool to be completely ruined at the end of 20 minutes (with an allowance of a minute or two each side of the 20 minute mark). In this way that cutting speed is found which corresponds to the particular thickness of shaving which is under investigation.

A change is then made in the thickness of the shaving, and another set of 20 minute runs is made, with a series of similar uniform tools, until the cutting speed corresponding to the new thickness of feed has been determined; and by continuing in this way all of the cutting speeds are found which correspond to the various changes of feed. In the meantime, every precaution must be taken to maintain uniform all the other elements or variables which affect the cutting speed, such as the depth of the cut and the quality of the metal being cut; and the rate of the cutting speed must be frequently tested during each 20 minute run to be sure that it is uniform.

The cutting speeds corresponding to varying feeds are then plotted as points upon a curve, and a mathematical expression is found which represents the law of the effect of feed upon cutting speed. We believe that this standard or method of procedure constitutes the very foundation of successful investigation in this art; and it is from this standpoint that we propose to criticise both our own experiments and those made by other investigators.

It was only after about 14 years' work that we found that the best measure for the value of a tool lay in the exact cutting speed at which it was completely ruined at the end of 20 minutes. In the meantime, we had made one set of experiments after another as we successively found the errors due to our earlier standards, and realized and remedied the defects in our apparatus and methods; and we have now arrived at the interesting though rather humiliating conclusion that with our present knowledge of methods and apparatus, it would be entirely practicable to obtain through four or five years of experimenting all of the information which we have spent 26 years in getting.

The following are some of the more important errors made by us:

We wasted much time by testing tools for a shorter cutting period than 20 minutes, and then having found that tools which were apparently uniform in all respects gave most erratic results (particularly in cutting steel) when run for a shorter period than 20 minutes; we erred in the other direction by running our tools for periods of 30 or 40 minutes each, and in this way used up in each single experiment so much of the forging that it was impossible to make enough experiments in cutting metal of uniform quality to get conclusive results. We finally settled on a run of 20 minutes as being the best all-round criterion, and have seen no reason for modifying this conclusion up to date.

We next thought a proper criterion for judging the effect of a given element upon the cutting speed lay in determining the particular cutting speed which would just cause a tool to be slightly discolored below the cutting edge at the end of the 20 minutes. After wasting six months in experimenting with this as our standard, we found that it was not a true measure; and then adopted as a criterion a certain definite dulling or rubbing away of the cutting edge. Later it was found, however, that each thickness of feed had corresponding to it a certain degree of dullness or injury to the cutting edge at which point regrinding was necessary (the thicker the shaving the duller the tool should be before grinding); and a third series of experiments was made with this as a standard. While experimenting on light forging a standard dullness of tool was used which was just sufficient to push the forging and tool apart and so slightly alter the diameter of the work. All of these criterions were discarded, however, when in 1894 we finally hit upon the true standard, above described, of completely ruining the tool in 20 minutes.

As will be pointed out later in the paper, this standard demands both a very large and expensive machine to experiment with, and also large, heavy masses of metal to work upon, which is unfortunate; but we believe without apparatus and methods of this kind it is out of the question to accurately determine the laws which are sought.

Experiments upon the art of cutting metals (at least those experiments which have been recorded) have been mainly undertaken by scientific men, mostly by professors. It is but natural that the scientific man should lean toward experiments which require the use of apparatus and that type of scientific observation which is beyond the scope of the ordinary mechanic, or even of engineers unless they have been especially trained in this kind of observation. It is perhaps for this reason more than any other that in this art several of those elements which are of the greatest importance have received no attention from experimenters, while far less fruitful although more complicated elements have been the subject of extended experiments.

As an illustration of this fact we would call attention to two of the most simple of all of the elements which have been left entirely untouched by all experimenters, namely:

(*a*) the effect of cooling the tool through pouring a heavy stream of water upon it, which results in a gain of 40 per cent in cutting speed;

(*b*) the effect of the contour or outline of the cutting edge of the tool upon the cutting speed, which when properly designed results in an equally large percentage of gain.

Both of these elements can be investigated at comparatively small cost, and with comparatively simple apparatus, while that element which has received chief attention from experimenters, namely, the pressure of the chip on the tool, calls for elaborate and expensive apparatus and is almost barren of useful results.

This should be a warning to all men proposing to make experiments in any field, first, to look thoroughly over the whole field, and, at least, carefully consider all of the elements from which any practical results may be expected; and then to select the more simple and elementary of these and properly investigate them before engaging in the more complicated work.[1]

It is a noteworthy fact that when thorough investigations are attempted by earnest men in new fields, while frequently the object aimed at is not attained, yet quite often discoveries are made which are entirely foreign to the purpose for which the investigation was undertaken. And it may be said that the indirect results of careful scientific work are, generally speaking, fully as valuable as the direct. Two interesting illustrations of this fact have been furnished by our experiments.

The discovery of the Taylor-White process of treating tools by heating them almost to the melting point, or, in other words, the introduction of modern high speed tools the world over, was the indirect result of one of our lines of investigation.

The demonstration of the fact that the rules for using belting in common practice furnished belts which were entirely too light for economy was also one of the indirect results of our experiments.

The manner of making these discoveries was each time in a way so typical of what may be expected in similar cases that it would seem worth while to describe it in some detail.

During the winter of 1894–95, the writer conducted an investigation in the shop of Wm. Sellers & Co., at the joint expense of Messrs. William Cramp & Sons, shipbuilders, and Messrs. Wm. Sellers & Co., to determine which make of self-hardening tool steel was, on the whole, the best to adopt as standard for all of the roughing tools of these two shops.

As a result of this work, the choice was narrowed down at that time to two makes of tool steel: (1) the celebrated Mushet self-hardening steel, the chemical composition of the particular bar analyzed at this time being as follows:

Tungsten Per Cent	Chromium Per Cent	Carbon Per Cent	Manganese Per Cent	Silicon Per Cent	Phosphorus Per Cent	Sulphur Per Cent
5.441	0.398	2.150	1.578	1.044		

[1] Here follows a description and criticism of certain experiments made in England and Germany. — Ed.

and (2) a self-hardening steel made by the Midvale Steel Company of the following chemical composition:

Tungsten Per Cent	Chromium Per Cent	Carbon Per Cent	Manganese Per Cent	Silicon Per Cent	Phosphorus Per Cent	Sulphur Per Cent
7.723	1.830	1.143	0.180	0.246	0.023	0.008

Of these two steels, the tools made from the Midvale steel were shown to be capable of running at rather higher cutting speeds. The writer himself heated hundreds of tools of these makes in the course of his experiments in order to accurately determine the best temperatures for forging and heating them prior to grinding so as to get the best cutting speeds. In these experiments he found that the Mushet steel if overheated crumbled badly when struck even a light blow on the anvil, while the Midvale steel if overheated showed no tendency to crumble, but, on the other hand, was apparently permanently injured. In fact, heating these tools slightly beyond a bright cherry red caused them to permanently fall down in their cutting speeds; and the writer was unable at that time to find any subsequent heat treatment which would restore a tool broken down in this way to its original good condition. This defect in the Midvale tools left us in doubt as to whether the Mushet or the Midvale was, on the whole, the better to adopt as a shop standard.

In the summer of 1898, soon after undertaking the reorganization of the management of the Bethlehem Steel Company, the writer decided to continue the experiments just referred to with a view to ascertaining whether in the meanwhile some better tool steel had not been developed. After testing several additional makes of tools, our experiments indicated that the Midvale self-hardening tools could be run if properly heated at slightly higher speeds than those of any other make.

Upon deciding to adopt this steel as our standard the writer had a number of tools of each make of steel carefully dressed and ground to exactly the same shape. He then called the foremen and superintendents of the machine shops of the Bethlehem Steel

Company to the experimental lathe so that they could be convinced by seeing an actual trial of all of the tools that the Midvale steel was, on the whole, the best. In this test, however, the Midvale tools proved to be worse than those of any other make; *i. e.*, they ran at slower cutting speeds. This result was rather humiliating to us as experimenters who had spent several weeks in the investigation.

It was of course the first impression of the writer that these tools had been overheated in the smith shop. Upon careful inquiry among the smiths, however, it seemed as though they had taken special pains to dress them at a low heat, although the matter was left in much doubt. The writer, therefore, determined to make a thorough investigation before finally adopting the Midvale steel as our shop standard to discover if possible some heat treatment which would restore Midvale tools injured in their heating (whether they had been underheated or overheated) to their original good condition.

For this purpose Mr. White and the writer started a carefully laid out series of experiments, in which tools were to be heated at temperatures increasing, say, by about 50 degrees all the way from a black heat to the melting point. These tools were then to be ground and run in the experimental lathe upon a uniform forging, so as to find:

(*a*) that heat at which the highest cutting speed could be attained (which our previous experiments had shown to be a cherry red);

(*b*) to accurately determine the exact danger point at which if over or underheated these tools were seriously injured;

(*c*) to find some heat treatment by which injured tools could be restored to their former high cutting speeds.

These experiments corroborated our Cramp-Sellers experiments, showing that the tools were seriously broken down or injured by overheating, say, somewhere between 1550 degrees F. and 1700 degrees F.; but to our great surprise, tools heated up to or above the high heat of 1725 degrees F. proved better than any of those heated to the best previous temperature, namely, a bright cherry red; and from 1725° F. up to the incipient point of fusion of the tools, the higher they were heated, the higher the cutting speeds at which they would run.

Thus, the discovery that phenomenal results could be obtained by heating tools close to the melting point, which was so completely revolutionary and directly the opposite of all previous heat treatment of tools, was the indirect result of an accurate scientific effort to investigate as to which brand of tool steel was, on the whole, the best to adopt as a shop standard, neither Mr. White nor the writer having the slightest idea that overheating beyond the bright cherry red would do anything except injure the tool more and more the higher it was heated.

During our early Midvale Steel Company experiments, extending from 1880 to 1883, the writer had so much trouble in maintaining the tension of the belt used in driving the boring mill upon which he was experimenting that he concluded: (1) that belting rules in common use furnished belts entirely too light for economy; and (2) that the proper way to take care of belting was to have each belt in a shop tightened at regular intervals with belt clamps especially fitted with spring balances, with which the tension of the belt was accurately weighed every time it was tightened, each belt being retightened each time to exactly the same tension.

In 1884, the writer designed and superintended the erection of a new machine shop for the Midvale Steel Company, and this gave him the opportunity to put these conclusions to a practical test. About half the belts in the shop were designed according to the ordinary rules and the other half were made about three times as heavy as the usual standard. This shop ran day and night. The belts were in all cases cared for and retightened only upon written orders sent from the shop office; and an accurate record was kept through nine years of all items of interest concerning each belt, namely: the number of hours lost through interruption to manufacture; the number of times each belt interrupted manufacture; the original cost of each belt; the detail costs of tightening, cleaning and repairing each belt; the fall in the tension before requiring retightening; and the time each belt would run without being retightened. Thus at the end of nine years these belts furnished a record which demonstrated beyond question many important facts connected with the use of belting, the principal of these being that the ordinary rules gave belts only about one-half as heavy as should be used for economy.[1] This belting experiment illustrates again the good that often comes indirectly from experiments undertaken in an entirely different field.

After many years of close personal contact with our mechanics, I have great confidence in their good judgment and common sense in the long run, and I am proud to number many of them among my most intimate friends.

As a class, however, they are extremely conservative, and if left to themselves their progress from the older toward better methods will be exceedingly slow. And my experience is that rapid improvement can only be brought about through constant and heavy pressure from those who are over them.

It must be said, therefore, that to get any great benefit from the laws derived from these experiments, our slide rules must be used, and these slide rules will be of but little, if any, value under the old style of management, in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed, and feed, he will use.

The slide rules cannot be left at the lathe to be banged about by the machinist. They must be used by a man with reasonably clean hands, and at a table or desk, and this man must write his instructions as to speed, feed, depth of cut, etc., and send them to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have been not only adopted, but enforced, throughout the shop for every detail, large and small, of the shop equipment, as

[1] The writer presented a paper to this Society in 1893 (published in *Transactions*, Vol. 15) upon this series of experiments. He has since found, however, that in the minds of many readers the value of the conclusions arrived at has been seriously brought into question largely through the criticism of one man, which at the time appeared to the writer so ridiculous that he made the mistake of thinking it not worth answering in detail. This should be a warning to writers to answer carefully all criticisms, however foolish.

well as for all shop methods. And, further, but little can be accomplished with these laws unless the old style foreman and shop superintendent have been done away with, and functional foremanship has been substituted, — consisting of speed bosses, gang bosses, order of work men, inspector, time study men, etc. In fact, the correct use of slide rules involves the substitution of our whole task system of management for the old style management, as described in our paper on "Shop Management" (*Transactions*, Vol. 24). This involves such radical, one might almost say, revolutionary, changes in the mental attitude and habits both of the workmen and of the management, and the danger from strikes is so great and the chances for failure are so many, that such a reorganization should only be undertaken under the direct control (not advice but control) of men who have had years of experience and training in introducing this system.

A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation that there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods. And this applies not only to large shops, but also to comparatively small establishments. In a company whose employees all told, including officers and salesmen, number about one hundred and fifty men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20 per cent upon the old volume of business into an annual profit of more than 20 per cent upon the new volume of business, and at the same time rendering a lot of disorganized and dissatisfied workmen contented and hard working, by insuring them an average increase of about 35 per cent in their wages. And I take this opportunity of again saying that those companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management who have had sufficient training and experience to insure success.[1]

[1] The writer feels free to give this advice most emphatically without danger of having his motives misinterpreted, since he has himself given up accepting professional engagements in this field.

Unfortunately those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples: Under our system the workman is told minutely just what he is to do and how he is to do it; and any improvement which he makes upon the orders given him is fatal to success. While, with the old style, the workman is expected to constantly improve upon his orders and former methods. Under our system, any improvement, large or small, once decided upon goes into immediate use, and is never allowed to lapse or become obsolete, while under the old system, the innovation unless it meets with the approval of the mechanic (which it never does at the start) is generally for a long time, at least, a positive impediment to success. Thus, many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on to the old system.

For this reason the really great gain which will ultimately come from the use of these slide rules will be slow in arriving — mainly, as explained, because of the revolutionary changes needed for their successful use — but it is sure to come in the end.

Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have 20 makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management.

There is, however, one element in which the new type of management to all outward appearance is far more complicated than the old; namely, no standards and no real system of management can be maintained without the supervision and, what is more, the hard work of men who would be called by the old style of management supernumeraries or non-producers. The man who judges of the complication of his organization only by looking over the names of those on the pay-roll and separating the so-called non-producers from the producers, finds the new style of management more complicated than the old.

No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require, as supernumeraries or non-producers on the pay-roll, a fireman, an engineer, an oiler and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of non-producers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

Now our whole system of management is quite accurately typified by the substitution of an elaborate engine to drive and control the shop in place of the old-fashioned foot power. There is no question that our human managing machine, which is required for the maintenance and the effective use of both standard shop details, and standard methods throughout the establishment, calls for many more non-producers than are used with the old style management having its two or three foremen and a superintendent. The efficiency of our engine of management, however, compared with the old single foreman is like a shop engine as compared with foot power or the drafting room as compared with having the designing done by the pattern maker, blacksmith and machinist.

A study of the recommendations made throughout this paper will illustrate the fact that we propose to take all of the important decisions and planning which vitally affect the output of the shop out of the hands of the workmen, and centralize them in a few men, each of whom is especially trained in the art of making those decisions and in seeing that they are carried out, each man having his own particular function in which he is supreme, and not interfering with the functions of other men. In all this let me say again that we are aiming at true simplicity, not complication.

There is one recommendation, however, in modern machine shop practice in making which the writer will probably be accused of being old-fashioned or ultra-conservative.

Of late years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, coupled with the maintenance and repairs, of this system will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs (in most shops entirely too light belts and countershafts of inferior design are used, and the belts are not systematically cared for by one trained man and this involves a heavy cost for maintenance). There is no question, therefore, that in many cases the motor drive means in the end additional complication and expense rather than simplicity and economy.

It is at last admitted that there is little, if any, economy in power obtainable through promiscúous motor driving; and it will certainly be found to be a safe rule not to adopt an individual motor for driving any machine tool unless clearly evident and a large saving can be made by it.

In concluding let me say that we are now but on the threshold of the coming era of true coöperation. The time is fast going by for the great personal or individual achievement of any one man standing alone and without the help of those around him. And the time is coming when all great things will be done by the coöperation of many men in which each man performs that function for which he is best suited, each man preserves his own individuality and is supreme in his particular function, and each man at the same time loses none of his originality and proper personal initiative, and yet is controlled by and must work harmoniously with many other men.

And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are:

Several men when heartily coöperating, even if of everyday caliber, can accomplish what would be next to impossible for any one man even of exceptional ability.

Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians; providing only that they are willing to pay the price in time, patience and hard work.

The old adage is again made good that all things come to him who waits, if only he works hard enough in the meantime.

Discussion

Mr. Henry R. Towne. Mr. Taylor's paper on "The Art of Cutting Metals" is a masterpiece. Based on what is undoubtedly the longest, largest, and most exhaustive series of experiments ever conducted in this field, its summary of the conclusions deduced therefrom embodies the most important contribution to our knowledge of this subject which has ever been made. The subject itself relates to the foundation on which all of our metal working industries are built.

2. About 60 years ago, American invention lifted one of the earliest and most universal of the manual arts from the plane on which it had stood from the dawn of civilization to the high level of modern mechanical industry. This was the achievement of the sewing machine. About 30 years ago, American invention again took one of the oldest of the manual arts, that of writing, and brought it fairly within the scope of modern mechanical development. This was the achievement of the typewriting machine. The art of forming and tempering metal tools un-

doubtedly is coeval with the passing of the stone age, and therefore in antiquity is at least as old, if indeed it does not outrank, the arts of sewing and of writing. Like them, it has remained almost unchanged from the beginning until nearly the present time. The work of Mr. Taylor and his associates has lifted it at once from the plane of empiricism and tradition to the high level of modern science, and apparently has gone far to reduce it almost to an exact science. In no other field of original research, that I can recall, has investigation, starting from so low a point, attained so high a level as the result of a single continued effort.

3. Measured by originality and comprehensiveness Mr. Taylor's paper undoubtedly is the most important thus far contributed to the Transactions of this Society. With perfect modesty it makes no claim to sole credit for the achievements it records, awarding due praise to all who were associated in the work, and recognizing that the work itself was made possible by the rapidly developing opportunities which modern materials, processes, and machines have made available, but which previously had not been fully appreciated or utilized. To Mr. Taylor is due all credit for being among the first to perceive these opportunities, to appreciate their possible significance, and, with endless patience and consummate skill, maintained through 26 years with unfaltering persistence and despite all discouragements, to carry forward his undertaking to its successful issue.

4. The title of Mr. Taylor's paper does scant justice to the scope of the work which it records, for incidentally to its main purpose this work included subordinate investigations hardly less radical, even if of less importance, than the main issue. Chief among these was the development of what is now best known as the "Taylor System" of shop management, itself a discovery of fundamental importance, the influence of which will be felt ultimately and permanently, not only in the metal trades but probably in all organized industry. Less fundamental, but still of universal interest and value wherever power is transmitted from a central source to large groups of power-driven machines, is the determination by Mr. Taylor of more correct and efficient

rules for the use of leather belting than were previously known. Another distinctive topic covered by his work is the proper forms of cutting tools and improved methods of making and maintaining such tools. Still another, and in some respects the most novel and brilliant of these many contributions to technical knowledge, is his adaptation of the slide rule to the determination of equations involving twelve variables, by a process so simple as to bring it within the reach of any skilled mechanic of fair intelligence.

5. The Society of which Mr. Taylor is the President, the Profession of which he is an honored member, and the industrial world are all to be congratulated on the achievements of which Mr. Taylor's paper, voluminous and comprehensive as it is, constitutes but a partial and inadequate record. While probably that paper is by no means the last word to be spoken on the subject to which it relates, certainly it is the most important and authoritative which has yet been uttered.

Mr. James M. Dodge. I want to just say one word about one word, and that is the word "task." It is a pity that our language has not another word that is more applicable to the meaning that Mr. Taylor gives to the word, but Mr. Taylor agrees with me that our language does not give us the exact word needed. Now, the "task" set by the Taylor System is n't a club which makes a man do twice as much as he did in the same way he has been doing it. The "task" set by Mr. Taylor, by the use of the prescribed tools and methods lightens the task; it does not add to the labor performed. It cuts out the unnecessary motions, and it renders the motions made more useful and more efficient by something supplemental. These motions are made, if we can use such an expression, as suiting a man's comfortable position or accomplishments. The men themselves who are doing these "tasks," say that they go home less tired than they used to do when they set their own tasks. So I say again that I regret that we have not a better word than task which according to our childhood lessons implies bother or burden, something which our teachers meant as a punishment to us. It is not a task; it is a help to the employee.

PREREQUISITES TO THE INTRODUCTION OF SCIENTIFIC MANAGEMENT

By H. K. HATHAWAY

GENERAL MANAGER, TABOR MANUFACTURING COMPANY, PHILADELPHIA, PA.

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Many remedies known to the medical world, unless taken in doses of the proper size and at suitable intervals, would produce dire results or none at all, whereas, when properly administered by a competent physician, they are a boon to humanity. "Scientific Management" may be compared to that class of remedies, and those who see in it a cure for many industrial ills must bear in mind that just as in medicine, fully as much depends upon the course of treatment being suited to the patient's individual condition and building up his strength to guard against a relapse, as upon the remedy.

It is not my desire to shake the faith of any convert to this new industrial teaching, but rather to outline the course that must be followed if success is to be met with in applying it.

There have been many instances in the past of the hasty assumption, on the part of managers and owners, of a greater knowledge of this subject than they really possessed; and even today, in spite of the wide publicity that it has received, there are many who, when scientific management is referred to, think that a wage system or cost system is meant. Too frequently the "form is mistaken for the substance," and an undue importance is attached to the printed forms and other implements that constitute the mechanism used in applying the principles.

The most common mistakes to be guarded against are: —

1. Undertaking, without sufficient knowledge and experience, the change from the old style of management to the new.
2. Under-estimating the magnitude of the task.
3. Lack of preparation.
4. Not taking the various steps in the proper sequence.

5. Going ahead too fast.
6. Lack of determination and perseverance.
7. Short cuts and ill-considered improvements.

The first step toward the adoption of scientific management should therefore be an educational movement, including in its scope every one from the directors down to the foremen, all of whom, before any start is made, should be thoroughly familiar with the principles and purposes of the new type of management and heartily in sympathy with it.

Unless there is a receptive spirit toward the new scheme, progress will be difficult — time spent in creating the proper mental attitude will be more than made up later on.

The superintendent and foremen must be made to feel that the adoption of the new type of management implies no criticism of nor reflection on their ability or integrity, but that it is rather a movement to make their efforts more effective through systematic coöperation, and that the results are to be beneficial to all concerned.

In his paper on "Shop Management" presented in 1903 before the American Society of Mechanical Engineers, Mr. Taylor lays great stress on the importance of the management thoroughly acquainting itself with the new scheme before its installation is undertaken, yet few readers fully appreciate its importance.

The following quotation from "Shop Management" brings out this point very clearly: —

Before starting to make any radical changes leading toward an improvement in the system of management, it is desirable, and for ultimate success in most cases necessary, that the directors and the important owners of an enterprise shall be made to understand, at least in a general way, what is involved in the change. They should be informed of the leading objects which the new system aims at, such, for instance, as rendering mutual the interests of employer and employee through "high wages and a low labor cost," the gradual selection and development of a body of first-class picked workmen who will work extra hard and receive extra high wages and be dealt with individually instead of in masses; and that this can only be accomplished through the adoption of precise and exact methods, and having each smallest detail, both as to methods and appliances, carefully selected so as to be the best of its kind. They should understand the general philosophy of the system and should see that, as a whole, it must be in harmony with its few leading ideas, and that principles and details which are admirable in one type of management have no place whatever in another. They should be shown that it pays to employ an especial corps to introduce a new system just as it pays to employ especial designers and workmen to build a new plant; that, while a new system is being introduced, almost twice the number of foremen are required as are needed to run it after it is in; that all of this costs money, but that, unlike a new plant, returns begin to come in almost from the start from improved methods and appliances as they are introduced, and that in most cases the new system more than pays for itself as it goes along; that time, and a great deal of time, is involved in a radical change of management, and that in the case of a large works, if they are incapable of looking ahead and patiently waiting for from two to four years, they had better leave things just as they are, since a change of system involves a change in the ideas, point of view and habits of many men with strong convictions and prejudices, and that this can only be brought about slowly and chiefly through a series of object lessons, each of which takes time, and through continued reasoning; and that for this reason, after deciding to adopt a given type, the necessary steps should be taken as fast as possible, one after another, for its introduction. They should be convinced that an increase in the proportion of non-producers to producers means increased economy and not red tape, providing the non-producers are kept busy at their respective functions. They should be prepared to lose some of their valuable men who cannot stand the change and also for the continued indignant protest of many of their old and trusted employees who can see nothing but extravagance in the new ways, and ruin ahead. It is a matter of the first importance that, in addition to the directors of the company, all of those connected with the management should be given a broad and comprehensive view of the general objects to be attained and the means which will be employed.

It must be realized by the owners and those at the head of a business that they are undertaking no easy task, nor is it one that can be accomplished in a few days, weeks, or months. A foundation must be built before erecting the structure, and it may be safely stated that no results of any consequence can be expected for at least a year, and more frequently two years, or even three. Scientific management is not a miracle worker. While, as Mr. Taylor points out, the system may in many cases pay for itself as it progresses, the owner must be prepared if necessary to spend a considerable sum of money before he gets any return, and must regard this expenditure in the light of an investment, just as he would regard, in starting a new business, the money spent in building and equipping his plant.

The cost of the undertaking is greater or less accordingly as the ground has been well or poorly prepared.

Any engineer who undertakes to direct the installation, or rather the development, of this system of scientific management in the works of a company where the right mental attitude does not exist courts trouble, failure, and the ultimate enmity of his clients. There is no use, nor is there any satisfaction, in doing this work for people unless they are enthusiastic, and their hearty coöperation is assured.

It is impossible, as those who have tried it know, for a manager to make much headway with the development of a new scheme of management, and at the same time carry on his regular work of running the plant; therefore, the next step after creating the right atmosphere is to secure the services of a competent management specialist to direct the work of reorganization. This is where many failures in the past have been made. Too frequently has the head of a concern, after visiting a plant in which this system is in successful operation, or after having read Mr. Taylor's paper on Shop Management, employed a bright but inexperienced young college graduate, given him the most meager outline of what was expected of him, handed him a few printed forms, and told him to go ahead and install a system. Without proper training, experience in handling workmen, or authority, it is but natural that he made no progress, and that he encountered the most active opposition from the superintendent, foremen, and workmen.

The management should beware of the self-styled expert whose qualifications consist chiefly of a stock of cant phrases culled from the literature of scientific management, which he glibly quotes in soliciting clients, who will offer to install a complete system in as many weeks or months as it would take years to do it properly. The wave of interest in this subject that has swept over the country is sure to bring out innumerable such "experts," some of them fakirs pure and simple, and others possessing that dangerous thing, a little knowledge, and honestly believing themselves qualified to systematize any industry under the sun.[1] As many crimes will be committed in the name of scientific management as have been committed in the name of liberty.

Assuming that the services of a properly qualified expert can be secured, he cannot be expected to do more than direct the work of developing the system, and training the men who are to do the work of getting it into working order and administering it when developed. These men should be selected from the existing force wherever possible, and in case they are not available, and it is necessary to bring in new men, they should be directly in the employ of the company, and not in that of the systematizer. This is almost imperative if the work done is to be of a permanent character. If new men must be brought in, they should be brought some time before the active development of the system is started, so that they will have ample time to become familiar with the plant and its output and to get acquainted with the other employees. These men should be started as workmen.

In theory it would appear to be desirable to have an expert with a corps of men trained in the various branches of the system do the work of installation, as under such a plan it should be possible to develop the system and get results much more quickly than by the slower method of training men from the company's force. The objection to that scheme, however, lies in the fact that the company's men would not feel the proprietary interest in the system, nor would they feel responsible for its success as they would if they had played an active part in its development. I doubt very much if a system installed in that manner would work at all, and am quite certain that its installation would meet with either active opposition or indifference on the part of the supervisory force, the value of whose interest and coöperation cannot be over-estimated.

During the period of preparation, many data can be collected that will be of value when the actual work of developing the system is started, and many minor improvements may be effected that will not only result in savings but make the change to the

[1] Cf. "The Mistakes of the Efficiency Men," p. 615. — Ed.

new methods less revolutionary, and more evolutionary, in character.

It is of the greatest importance that the various steps in the development of the system be made in the proper sequence. For example, it would be foolish to start taking time study and instituting task work with a bonus, or differential piece work in a machine shop, until standard conditions had been established and the scheme and mechanism for routing work through the shop developed; yet this is what many owners and managers want to do. Not only must the various steps be taken in the proper sequence, but none may be omitted.

The officers and directors of a company are, as a rule, quick to perceive and to admit the value of setting tasks, paying a bonus, and doing those things that make it easier for the workman to accomplish a large day's work, — such as keeping machines and tools in first class condition, and having the tools and materials for each man's next job placed at his machine for him in advance — but yet they think that the clerical work incident to planning, preparing written instructions and orders covering each step should be dispensed with. Of course, this would be fine if it would work — but it won't. There can be no short cuts. If the system is to be successful and enduring, it must be adopted in its entirety.

Frequently owners and managers are encountered who say "there are some features of this system that I think are good; for instance, I think the laying out of the work on a bulletin board is excellent, but I don't see the need of making out route sheets, move orders, and inspection orders for each operation." Or, "I like the task and bonus scheme but I do not see the necessity of writing elaborate detailed instruction cards for each operation."

To explain the reasons and principles back of each of the elements of scientific management would fill many volumes; suffice to say that there is a good and sufficient reason for each, and that all are necessary to make up the complete machine, which will not run if one is omitted any more than the best steam engine in the world will run if the piston is dispensed with.

The speed at which the system develops depends very largely upon existing conditions, and how well preparations have been made. In a concern that has been well managed under the old scheme, it will be much more rapid than in one that has been badly managed. It is not only impossible, but exceedingly unwise to expect or attempt to correct, in a few weeks or months, the evils and faulty practice that have crept in during years of the old style of management.

Not only must prejudice be overcome by object lessons and reasoning, but frequently physical changes must be effected; workmen, foremen, superintendents, and others must be trained to new habits of thought and action, while at the same time there must be no falling off in output.

If the work done and the results achieved are to be enduring, the system can be developed only so fast as the people who are to use it and live with it can absorb it. One of the most difficult and trying tasks of the man directing the development of a system of scientific management is to curb the impatience of the owners at certain stages, and at others to sustain their courage and faith.

Once it is decided to adopt scientific management, and its development is started, it must be clearly understood by everybody concerned that it is going through. There can be no halfway course in this respect, no ifs, no "giving it a fair trial." More good things fail through being "given a fair trial" than for any other reason. They are damned from the start. There must be a determination to make it go, and if at first it does fail to work at any point, no one must be permitted to say supinely, "we tried it, but it did not work." Then is the time to go at it with renewed vigor, backed up by unwavering faith, and keep at it until it does work. Failures of any sort are not due so much to the obstacles encountered, as to the lack of determination to overcome them. Nothing has a more demoralizing effect than any semblance of wavering on the part of the management, the slightest evidence of which communicates itself throughout a working force in a most uncanny way, producing a spirit of indifference, incredulity, and often insubordination that increases the difficulties of the task many-fold.

The tendency to "jump fences" and take short cuts must be guarded against, especially on the part of the higher officials, who are more inclined than any one else to make this mistake. In the change to functional management, it is rather difficult for a man whose authority and responsibilities have covered every field, to keep within the lines and to transmit orders through the proper channels. The natural inclination for these men, when they desire information or want anything done, is to go directly to the man in the shop who, under the old order of things, would be the right person, ignoring the fact that under the new scheme the function of this man is completely changed, and that the application should have been made to the planning department. In such cases the man in the shop should of course refer him back to the planning department, but his respect for the authority of the higher official as he knew it under the old scheme is so deeply rooted, that he instinctively and with the best intentions proceeds to act on the orders received, which may be directly at variance with those of the planning department, as well as outside the range of his duties as defined by his new function, and conflicting with those of another.

During the early stages of the development there must be many things done which at that time do not appear to serve any purpose, but which are the foundation and framework for future steps, and are for that reason of the greatest importance.

There will be well meant criticism of everything done, and suggestions galore of better methods than those installed, especially in regard to the forms and appliances and their use; but if progress is to be made, these suggestions and criticisms must be disregarded. It must be realized that the methods and mechanism of scientific management are the result of years of evolution and development, and that they have been adopted as necessity made itself felt. Many apparently better and quicker ways that will suggest themselves have been tried, found impractical, and discarded years ago, and are what is known in the vocabulary of scientific management as "Damned improvements." I do not mean to imply by this that the methods and mechanism of scientific management cannot be improved upon, but they are the best that are known today to those who have made its study and application a life work. With almost every instance of its installation some new and better element is found and adopted, but the only safe and economical course is to get it working in its existing form before undertaking to improve it.

It might be added in conclusion that the undertaking must be as much for the good of the workmen as for the stockholders, and that its aim must be to help them, through systematic and practical coöperation, to produce, in many cases with less effort, much more work than formerly, rather than to drive them to unreasonable exertion. Feverish haste, driving, injustice, and bluff have no place in scientific management, and it must be recognized from the start that the square deal, and a proper regard for the workers' welfare, both physical and otherwise, are essential to success.

ON THE ART OF CUTTING METALS

SELECTIONS FROM THE DISCUSSION OF MR. TAYLOR'S PAPER

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MR. CALVIN W. RICE. As an incident to the introduction of system in a certain shop it became necessary to conduct the experiments of which the presidential address is a résumé. I say an incident, but it would probably be more correct to speak of the address as a record of many incidents to the introduction of the Taylor system.

2. The system is universal of application, and the mastery of the art of cutting metals was simply one of many things to do to make a success of the system. As the system is applied to other industrial establishments, we may in turn expect papers on the arts pertaining to them, such as the art of bleaching cotton goods, etc.

3. This situation is not peculiar to the Taylor system. Mr. Edison has been busy the last few years not so much in inventing a storage battery as in the development of the art of the manufacture of materials that go into the composition of the battery. Were it not a digression I would like to go into the subject in detail.

4. Therefore the good from modernizing engineers is far reaching. This fall I had the opportunity to visit the Sayles Bleacheries, located near Pawtucket, R. I., where the Taylor system is being introduced,[1] and with your permission, I will offer as a discussion on this paper a few remarks on what I saw there, the object being to show the applicability of scientific method and the benefit derived from such application to any form of industry.

5. It is well to observe here that one cannot effect these improvements without, first, complete submission of the manage-

[1] Under the professional direction of Mr. H. L. Gantt. — ED.

ment of affairs to the one introducing the system,[1] and, second, additional people to the regular establishment. There is no compromise between the old and the new because they are fundamentally opposed. It is only folly to try it because it is a physical impossibility for the regular staff both to conduct the regular business and simultaneously master and apply the new system.

6. In the Sayles Bleacheries I was permitted to compare the record of the output of certain rooms before they began to introduce the system with what is now being done, and even in the most simple matters, namely, folding cloth, the increase in output was very great, individual cases fivefold, and the increase of individual wages 20 to 40 per cent. The cost per piece was of course reduced.

7. Improvements in other bleacheries, competitors say, have of course been going on also, so that the Sayles have no monopoly in this regard, but what they do have over their neighbors is a better class of employees with higher individual wages, freedom from labor difficulties, because the Taylor system does not conflict with the bulls of labor unions, and more than all, an organization capable of indefinite expansion to meet any emergency.

8. It would be out of place, and perhaps breach of confidence to go into further details. Suffice it to say, that in this world of competition intelligent organization based on scientific investigation is the *sine qua non* of success and that no amount of work or years of investigation necessary to obtain the result should deter the investigator.

MR. H. K. HATHAWAY. It is to be hoped, and is highly probable, that many superintendents and managers of machine shops will undertake to make use of the invaluable data that Mr. Taylor has so generously made available to thousands, who, through limited facilities and time, would otherwise be unable to acquire more than an inadequate and superficial knowledge of

[1] Since this discussion the practice of the Taylor group has changed, and it is not now customary for the management expert to take executive control of the business. His function is now that of adviser and instructor with executive power applied only to the development of his system work. — ED.

this vitally important branch of manufacturing, and that as a result the manufacturing world may be as greatly benefited by exact knowledge of what can be accomplished in cutting metals, as it has already been benefited through the invention and general use of high speed steels.

2. I should like, however, to call attention to a grave danger that will confront all who undertake to attain the results that Mr. Taylor has shown to be possible, which, unless properly guarded against, will cause all such attempts to end in disastrous failure and disappointment. This danger is, that despite the fact that Mr. Taylor has clearly stated the necessity for first establishing such conditions as will make it possible to always and definitely answer the "questions which must be answered each day in every machine shop," as to the kind of tool, the feed, speed and depth of cut to be used, and to make use of the answer after it is given, many will undertake to apply the knowledge contained in Mr. Taylor's paper without any preliminary preparation to insure the successful outcome of such an attempt.

3. In many cases such an effort will cease after the workman running the machine, when told to use a certain feed, speed, or depth of cut, replies in a convincing manner that the machine won't stand it, or that the job he is working on is of such a peculiar nature that such a heavy cut would spoil it by "springing" it or making it come "out of round." If the foreman is still unreasonable enough to insist upon his trying it, he will either quit, or proceed, more in sorrow than in anger, to prove the truth of his statements, and the foreman will probably lose heart after the following things happen: The cone belt will slip and have to be tightened; next the countershaft belt will slip and have to be tightened, then if the belts pull the cut without breaking in two or pulling out at the lacings, it will be found that the carrier, driver or chuck will not hold the job.

4. After surmounting these difficulties and having the tool break or fall down through having been improperly treated and ground, the foreman will find that for about three hours he has neglected important matters in other parts of the shop and will conclude in the future to mind his own business and leave such

matters as feed and speed to the judgment of the man running the machine, who from his daily experience ought to know better what the machine and tools will do than any one else in the shop.

5. Having been through all this myself, I know pretty well the opposition and difficulties that will be encountered, and feel that too much stress cannot be laid on the importance of overcoming them before they have a chance to arise, and I have become a strong believer in the "ounce of prevention" theory, provided it is applied, not in a spasmodic manner, but systematically and continuously.

6. To cite an instance of what may be expected when one undertakes to speed up the average shop, I should like to mention an experience of my own that happened a few years ago, when after having passed through the various stages from apprentice to foreman, or "overseer," in the machine shops of the Midvale Steel Company, where I was accustomed to see rapid and heavy cutting, and also men obeying orders as to speeds, feeds, etc., and to have belts heavy enough and maintained to a tension that assured their pulling all that the tool would stand, I accepted a position as superintendent with a small concern, where the workmen, under the sole direction of one "overworked foreman," ground their tools to suit themselves, repaired and cared for their own belts, and followed their own judgment or inclinations as to the feeds, speeds, cuts, and kind of tools to be used.

7. I was amazed at the light cuts and slow speeds I found in vogue, as well as the many peculiar shapes of tools in use, and attempted at once to get things up to the speed that I had been used to at Midvale, with the result that I encountered all the obstacles previously enumerated and found that the custom in that shop, when a belt slipped, was to reduce the speed or feed to a point where it would pull, as the workman reasoned that it was less trouble to do so than to tighten the belt.

8. Another drawback to using the proper feeds and speeds was that the tools were of every conceivable shape and kind of steel, a bar or two having apparently been bought from every tool steel salesman who came along, and as the workman had no means of

identifying the tools made of good high speed steel from those made of old carbon or early self-hardening steels, he ran the speed suited to the latter, to be sure that his tool would not give out during a cut.

9. After I had managed to get the belts, tools, and driving mechanism on a few of the machines in such a condition that something like the proper speeds and feeds could be used, I found that it was utterly impossible, with one "overworked foreman" (who did not take very kindly to my notion of speeding up, anyway) to insure such conditions being maintained continuously, and that while I might get a workman to run the proper speed on a certain job today, if left to himself the next time that job came up he would be running the same old speed and have the same old reasons for doing so.

10. About this time I learned another fact that has since been of great value to me, and that is, it is exceedingly unwise to expect to attempt to correct the evils of years of bad management and faulty shop practice, or to bring about a change from the minimum of efficiency to the maximum of efficiency in a few days or weeks or even months.

11. In the shop referred to, I attempted to install the premium plan, based on carefully kept records, which I later found to be absolutely inaccurate and unfair, and to get the shop up to the speed that I knew to be possible, in about three months' time, with the result that at the expiration of that time I had a strike on my hands which pretty nearly put the company down and out, and solely because I began at the wrong end, instead of first taking steps to insure the success of my efforts; first, by standardizing, and making such improvements in the belting, tools, and appliances as were necessary in order to make it possible to get the same results as were being attained at Midvale; secondly, by providing a system or mechanism for keeping them up to the standard once attained; thirdly, by replacing the one "overworked foreman," who was expected to know it all and do it all, by a planning department which would each day assign for each workman a definite task to be performed in a definite time, and prepare instruction cards showing just how each should be

done and what speeds, feeds, and tools should be used, and by several functional foremen in the shop, each of whom would have specific and well-defined duties, for which his temperament and training fitted him; who would coöperate in seeing that all work was done in the manner planned and that the standards were maintained.

12. It seems to me that my undertaking to apply in this shop the feeds, speeds, and cuts that I had used, and seen used continuously at Midvale, is analogous to undertaking to apply the information on the " Art of Cutting Metals " contained in Mr. Taylor's paper, in the average machine shop without any previous preparation to insure a successful outcome of such an undertaking, and it is devoutly to be hoped for their own sakes, and in fairness to Mr. Taylor, that all who do hope to benefit by Mr. Taylor's vast experience in this line will begin at the right end and in the right way which Mr. Taylor has pointed out and which I am convinced, from my experience in the matter, lies in the application of the principles set forth in his paper on " Shop Management," and which can only be successfully applied through a system of functional management, where every man from the manager down has a definite task to perform in a definite way and by the establishment and maintenance of rigid standards.

13. Unfortunately such a system as Mr. Taylor's cannot be bought and delivered in a box, but must be installed step by step until the final goal is reached, when a definite task is given each workman each day in advance with detailed written instructions and an exact time allowance for each element of the work, and this installation calls for such an amount of hard work, close and incessant following up, and minute study of conditions as to make it impossible for any man who has routine work to do in connection with the running of a plant, to undertake it with any hope of success, but will call for the undivided attention of an experienced man, who must have the heartiest and most sincere backing and support of the management in the face of the opposition and prejudice that is sure to be encountered. Even then, there will be times during the period of revolution from the old to the new system of management, when it will appear as though

the business is going to ruin, when the greatest faith in the soundness of the principles upon which this system is based will be required to carry one through them, but the reduced costs, increased output and harmony that are bound to result in the end are sure to pay many times over for the labor and expense incurred in making the change.

THE SPIRIT IN WHICH SCIENTIFIC MANAGEMENT SHOULD BE APPROACHED

By JAMES MAPES DODGE

CHAIRMAN OF THE BOARD, THE LINK-BELT COMPANY, PHILADELPHIA, PA.

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The old saying that "each one of us endeavors to measure all things in his own pint pot," I am free to admit, applies very well to me, for while the title which has been assigned to me assumes a much broader treatment than a mere recital of personal feelings, the best I can do is to draw freely on personal experiences, disguising them by eliminating the personal pronoun and giving them an air of general application. In this endeavor, therefore, let us talk of the spirit in which we approach Scientific Management.

The term Scientific Management is possibly not the best; many establishments that can lay no claim to any comprehensive scheme of organization contain within them elements of successful management. Mr. Taylor in his treatise on the subject used the title "The Art of Management," while others in speaking of Mr. Taylor's work refer to it as a "Conservation of Human Efforts through the Art of Management." Certainly, where human elements are introduced into a problem, scientific methods alone will hardly achieve a complete solution. It must be a combination of scientific analysis and methods plus consideration for the interest and well-being of the workers, and tact in meeting their inherent resistance to change, or their natural prejudice against something of which they do not understand the full import. Many concerns succeed because they have taken care of this human side of the problem, even though they lack scientific methods of procedure and exactness of information. Other concerns which expect to reduce management to an algebraic formula fail in the attempt because they neglect to foster growth and initiative in the working force. These concerns have lost sight of the human side of the problem. Truly *Scientific* Management takes account of both sides of the problem, and the method of approach should lie along both of these lines.

The most primitive form of management exists in those establishments in which the owner "carries his office in his hat." When the establishment grows beyond the capacity of the contents of one hat, power and responsibility are delegated to others, until these too become overtaxed. Costs go up, deliveries fall off, and the necessity for a further distribution of authority and responsibility arises. This gradual delegation and subdivision of authority and responsibility is characteristic of what Mr. Taylor terms the "Military System of Management." Under it the shops are run almost entirely by the foremen, and the actual work is performed by men working under constant criticism and goading. The foremen have ideas of management more or less at variance with each other, but the proprietors accept the results as the best that can be obtained, without any proper or regular investigation. The workman who calls at the gate is supposed and expected to be an expert, requiring no instruction or help; the foreman is expected to know how to perform all the duties of his position, and the superintendent is assumed by the owner to know how to manage shop affairs to the practical limit of the possibilities. In such a form of management, criticism from the head goes completely down the line, gathering in vehemence and force as it proceeds, while praise extended from the top usually penetrates only as far as the superintendent's office.

Despotic authority which manifests itself in harsh criticism or tyrannical treatment of the men is undoubtedly the characteristic feature of this form of management. Money returns are the only gage of success, and that foreman is best who can force from his men the greatest amount of work with the least possible compensation. From such methods the men have no redress except to seek employment elsewhere. The general recognition of the fact that the workmen have rights and that the remark, "You don't have to work here unless you want to" is not a proper answer to a legitimate complaint, is one of the factors which is creating a demand for a general change in methods of management.

It is a serious thing for a worker who has located his home within reasonable proximity to his place of employment and with proper regard for the schooling of his children, to have to seek other employment and readjust his home affairs, with a loss of time and wages. Proper management takes account not only of this fact, but also of the fact that there is a distinct loss to the employer when an old and experienced employee is replaced by a new man who must be educated in the methods of the establishment. An old employee has, in his experience, a potential value that should not be lightly disregarded, and there should be, in case of dismissal, the soundest of reasons, in which personal prejudice or a temporary mental condition of the foreman should play no part.

Constant changing of employees is not wholesome for any establishment, and the sudden discovery by a foreman that a man who has been employed for a year or more is " no good " is often a reflection on the foreman, and more often still, is wholly untrue. All workingmen, unless they develop intemperate or dishonest habits, have value in them, and the conserving and increasing of this value is a duty which should be assumed by their superiors. There is humor and sense in the declaration of the colonel in the *Pirates of Penzance*, " I lead my regiment from behind, I find it less exciting " ; for instead of spurring men on by damning them from the front, it is more profitable and more effective in the industrial campaign to extend a helping hand to those in the rear, furnishing them with proper manual and mental equipment to keep up with their fellows.

Under this method the most successful superintendents and foremen are those who can best aid and encourage their subordinates to make the most of themselves and their opportunities, removing obstacles from their paths and enabling them to earn greater rewards without overtaxing their mental and physical abilities. In other words, Scientific Management consists in the cultivation of the best productive methods. Information can much more economically be ascertained by the leaders, and the knowledge transmitted to the workingmen, than it could be were each man to endeavor to ascertain it for himself.

Probably with all of us it is more difficult to accept a modification of a belief than to absorb a most startling or revolutionary new idea which does not call for any reversal of a notion to which we have tenaciously held. So in this matter of management it was, and is, and always will be essential for us to keep a hopeful equilibrium during transition from our old to our new love; and this transition period is certain to be a trying one.

In the establishments with which I am connected conversion came slowly to nearly all, and some of those who, it would seem, should logically have accepted the innovation with avidity, seemed temperamentally incapable of such acceptance. Those who live entirely in the present, without thought of the future or of the past, can easily acquire the habit of doing things in a new way; but those having active minds are apt to waver between the necessity of advancing a decision and the fear of error born of caution and imagination. Even a measure of intelligence might show that an ardent accepter of Scientific Management and a man unalterably opposed to it in every form, are of the same brain capacity. There is temperamental sectarianism in every profession and walk of life, inexplicable because temperament is inexplicable. We all know men who feel that no one can do things for them as well as they can do them for themselves. It is, of course, possible that there are certain things that the individual can do for himself better than any one else can do them for him; but there are, undoubtedly, thousands of things which can be better done for him by others. Should a man decide that before he looks at an eclipse he must become a thorough astronomer, he will, of course, eventually gain more from looking at the eclipse than those who rush out at first call and are satisfied to wonder at the phenomenon; but this same temperament might lead a man, if taken sick, to study the medical art until he had become a graduate physician, or to decline to deposit his money in a bank until he had mastered the intricacies of banking, and so on in all the accepted matters of our lives. So it is with some in considering the question of management; instead of investigating in an open-minded way the logic and results, they elect to question every minor step and consider that they must be accorded a complete vindication and proof of the other man's ideas before they are willing to lessen their grip on preconceived and opposing convictions. In other words, we haven't mental legs enough to permit us to maintain a position of straddling both sides of every presented question. It is therefore essential, in order to use the new system of management, that a man have within him a desire to travel in that direction, and that he aid to the best of his ability in the removal of small, real or imaginary obstructions, rather than hold back and allow all his progress to be brought about by the pressure of the breeching, or the pull at the halter. As a matter of fact, it seems that all of us need Scientific Management. If we naturally have it in sufficient quantity we certainly need what we have, but may not need any more. If we have none at all, it would be absolutely ridiculous to say that we could not make good use of some. The degree and quantity are regulated, possibly, not so much by our thoughts as by the invincible logic of progress and existing conditions.

It would of course be ridiculous for an employer of one man to undertake the introduction of Mr. Taylor's "Art of Management," but if he were familiar with some of the underlying principles promulgated by Mr. Taylor, it would undoubtedly be of value to him. The question of exactly how large an establishment should be or how small an establishment may be to introduce Scientific Management in it with profit and success is of course impossible of numerical answer, because it is dependent upon so many things. It might be likened to what we call civilization. There can be no dissent to the general statement that civilization is beneficial, but, if by civilization we mean everything in general and in detail that is properly a part of the system of civilization, it would be very difficult for any one to say, provided an uninhabited island were discovered in the Pacific Ocean, that in colonizing it, civilization in its fullest sense could be applied to five, ten, one hundred or some other definite number of people. At the same time, it is quite evident that even one person on this island would be immensely benefited by some elements of modern civilization. In fact, so important would it be to this individual that his very life might depend upon it. On the other hand, if some overwhelming power should decree that he must use every bit of civilization, his speedy demise would be absolutely certain; and so it is in the matter under discussion. Life is too short, individuals and people too circumscribed by their senses and surroundings, to see, feel and believe that they need Scientific Management in its entirety. Nevertheless, no establishment is so small, no business so primitive, but that Scientific Management has details or suggestions that would be helpful. This would indicate that there is no way to define exactly the spirit with which each individual or establishment should approach this subject. It may for all time be governed by temperament, training and the necessities of each individual case. Of course, if an individual has inquired into Scientific Management with a view to adding to his stock of ammunition with which to blow it up, and to pose among his friends as a person of superior intelligence because he says a few bitter or apparently clever things in opposition to the remarkable wave of managerial awakening throughout the civilized world, no good is gained; on the other hand unthinking, untrained acquiescence is probably equally wide of the mark, and only a conscientious investigation of the subject will indicate its value and its best plan of application.

Let us assume that a man having heard of the " Taylor System " is possessed of the idea that he would like to find out something about it. It is more than likely that this individual has been in the commercial rather than in the practical side of manufacture, and he may be entertained because he has heard rumors that economy is effected and that profits are augmented by the system. Should he send for all the papers that have been published on this subject by the American Society of Mechanical Engineers and read them, however carefully, I fear he would become somewhat confused, inasmuch as a great deal that has been written in these papers, not being directly in line with his personal training and experience, would be obscure and difficult of understanding. He would, however, gather from it that an effort for economical production had certainly been made, and that it is on different lines from those efforts which might be called " of an older school." On the other hand, should the individual be entirely of a mechanical or a manufacturing turn of mind and of only corresponding experiences, his reading of this literature would set in motion an entirely different train of thought. He would find much more in the papers intelligible to him, but as many of the statements would be apparently at variance with his own previous experience, he would be inclined to be very critical of minor details, although in general acquiescent with the main ideas of the papers. In both cases, however, there would be an awakening of interest in the subject which would not be easily put to rest without further knowledge.

Then would come a period of discussion with those having interest in the subject and the clarifying of a great deal which was at first obscure and vague. This result is brought about by a lapse of time, and time is as necessary an element in making a proper impression on the human mind as it is in making a proper actinic impression on a photographic plate. In the latter case we have slow plates and quick plates, and they are acted upon by wide angle, telescopic and numerous other lenses; but human beings have the lenses of their senses sometimes out of focus, which has a potent influence in the registration of impressions upon their minds. After these impressions are registered, — some slowly, some quickly, some befogged by over-exposure, others deficient on account of under-timing — there comes another necessary and essential lapse of time, and that is in the development of the impressions, either in our brain or on the photographic plates, as the case may be. Now, this development is usually a much greater absorber of time than the mere registering of the impression; and then after the exposure and development comes another period, much longer still, and which may be never-ending, and during which proper use is made of the now developed impressions. Photographic failures are many, but probably not so numerous, proportionately, as mental failures;

so we must make ample allowance for variations in the impressions which, apparently, the same exposures may make on different mentalities.

It is almost needless for me to say that the mentality which would receive the initial impressions with proper speed and develop them into their most useful forms is the one that I must talk about, otherwise my task would be endless and your interest entirely used up. We will therefore assume that an individual has received proper impressions, that they have been properly developed, and that it has become his earnest desire properly to introduce Scientific Management into his establishment. The first step, even though he is the sole proprietor and theoretically can do exactly as he pleases, must of necessity be to interest some of his associates. This he will find, as I have previously stated, is not in every case an easy proposition, for the reason that temperamental differences in individuals will require varying degrees and kinds of explanations, and the setting forth of the reasons in different mentally palatable ways. He will of course find, when he approaches his subordinates and they in various degrees accept his views with the feeling that something can be done of advantage to the establishment, that in no case will his leading men consider that anything in this new-fangled management business should be in any way applied to them, though they can see with greater or less degree of certainty that it would be admirable for everybody else in the place. The problem of overcoming this mental condition is the most difficult of all. The very fact that the leading men of an establishment are beholden to their cleverness and independence of thought for their promotion makes it certain that they will not hesitate to combat the views of their superior, if in their judgment it seems best. In other words, they are not disposed to take orders blindly and do that which they consider ill-advised or unnecessary. Consequently they will ask many questions, and probably it will be necessary and desirable to send some of the leading men out as investigators to go through other establishments and see for themselves what results have been obtained from the innovation. When they return they will not only have seen a good deal that will be entertaining to them, but will be in much better shape to discuss the subject further with their employer.

Then comes the period of incubation of the best plan to pursue in beginning the actual work of the introduction of Scientific Management. If the establishment has good use for all of its leading men and they are properly and rationally busy, it is quite obvious that they cannot devote their time to the acquisition and introduction of all the details of Scientific Management, as well as keep up with their regular lines of work. Therefore it is desirable to call in the services of some one who can bring knowledge and experience to play, to begin the actual introduction. As soon as this is done two forms of activity manifest themselves; one, strange to say, not the easiest to regulate, is the well-meaning unasked-for assistance to the introduction which usually takes the form of suggestion of improved methods in details that are clearly improvements in the mind of the suggester, but are impossible of acceptance on account of a conflict with other portions of the system to be introduced. This form of activity may be likened to a chorus in which many of the individuals decide that more or less volume of sound, or a change of tone or time, would be better than to follow the dictates of the leader and to sing the music as set before them. The other development is one either of open or sullen opposition. Frequently proper explanation and patience will overcome this form more easily than the other. The over-zealous cannot be properly curbed without their feeling that they have been " sat upon " or harshly dealt with. I am speaking of these as though they were phases which cropped up and could be disposed of. They can be disposed of in time, but again the time element comes in, and courage, patience and perseverance are required on the part of those at the head of the concern to a much greater extent than would be dreamed of before they had had the experience.

A great deal of care and thought must of course be given to maintain the business of the establishment in all its details while changes are being made, and to avoid having clashes and conflicting methods work hardship to the customers or to the profit-showing of the concern. It is quite obvious that it will be only a short time before two systems are being used in the same establishment, and it will require all the ability available to put up with this state of affairs until the new displaces the old; and probably this is the most trying time for the leading men all through the establishment, because in the stores department, order department, shipping department, and, in fact, all the departments, extra work and vigilance are required of every one in order that the confusion may be reduced to its lowest point. In spite of everything, however, there will be days when it will take courage on the part of individuals, and, in fact, courage on the part of the whole management, to keep moving manfully ahead and not to be stampeded by the trying conditions. After a while, however, the benefits of the system will begin to manifest themselves so strongly and the new methods will reveal themselves so satisfactorily, that all will become buoyantly interested and work with redoubled vigor to hasten the entire consummation of the introduction.

So far as the workmen themselves are concerned very little difficulty is experienced. It is essential, however, that the workingman should be told the exact truth, and under no circumstances should anything be done which has even the appearance of taking advantage of him. He must appreciate that his interests and those of his employer are mutual, and that their happiness and success depend upon mutual trust and consideration. If employers think that by the introduction of Scientific Management they can gain an advantage over the workers, they are making a serious mistake and wasting their efforts in what will eventually turn out to their great and lasting disadvantage. The whole scheme is one of mutual advancement and the corner-stone of the temple of the "Art of Management" is truth; the abutments must be truth, and every stone in the structure must be truth.

Herbert Spencer said that there is a principle which is proof against all argument, and which cannot fail to keep a man in everlasting ignorance; this principle is to condemn before investigating.

THE SUCCESSFUL OPERATION OF A SYSTEM OF SCIENTIFIC MANAGEMENT

By Lieut. FRANK W. STERLING

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The object of this paper is to present the practical working and routine of a system of modern management as applied to a plant, and particularly to describe the planning and production, personnel, routine, forms and cost keeping. The system at this plant has been much simplified since its installation, resulting in a decrease in the non-productive force, simplification and reduction in the number of forms used, abandonment of the mnemonic classification of stores (in this respect I am firmly convinced that the mnemonic classification of tools should eventually be abandoned), and numerous other improvements. The mnemonic classification of stores is impracticable where a large variety is carried.[1]

In some cases it was found that functions performed by two men could be done by one, and in addition to reducing the non-productive force a move of forms was avoided, thus decreasing the planning time. All this developed as the planning department force became expert and individually were capable of performing more varied functions.

In comparison with the other plants I have visited this one leaves a very strong impression of thoroughness, simplicity, economy and success. Six weeks' study of the working of their system confirms my opinion on all the above points.

The system employed was originally installed by Mr. F. W. Taylor and contains all of the essential elements of Mr. Taylor's system. It has been modified as experience and necessity have dictated and has been simplified to such extent as to excite most favorable comment. All changes have had Mr. Taylor's acquiescence.

[1] This conclusion is not borne out by experience. On the contrary, the value of the mnemonic classification has proven to be greatest where the number and variety of stores carried is largest. — Ed.

DISTRIBUTION OF PERSONNEL

Productive force, in % of total of men employed	67
Planning department	5
Draftsmen	15
Clerks, etc., main offices	13

ORGANIZATION

(Chart I to be read concurrently.)

Superintendent. — Since the position of assistant superintendent has been abolished the superintendent's functions have become very comprehensive, combining general management of planning, shop and production, with general superintendence of the planning for personnel. His executive power is in proportion to his functions, being absolute in the planning department, shops, shipping, employment and to a certain extent in the pay department.

Planning Department. — The function of the planning department is to aid production by allotting the work, routing and laying it out, designating the tools to use, speeds, feeds, cuts, etc., to take on the machine, drawing and inspection cards numbers, and any other data that will facilitate production.

Since the system was installed in this plant the planning department has been gradually reduced until no further reduction is possible. The smallness of this department (7% of the size of the productive departments) impresses itself at once. This reduction has been made possible by gradually simplifying the original system, although the advocates of this system consider it a paragon of simplicity.

Comparing the planning department with one other very successful one in the same city, we find that, whereas this one has been reduced to 7% the other remains at about 35% of the productive shop force. The fact that both plants have been very successful induces thought. Even in scientific management there are, apparently, many ways of arriving at the same result, and the old arbitrary methods of the foremost teachers must eventually make way for common-sense methods based on earnest thought and managerial ability.

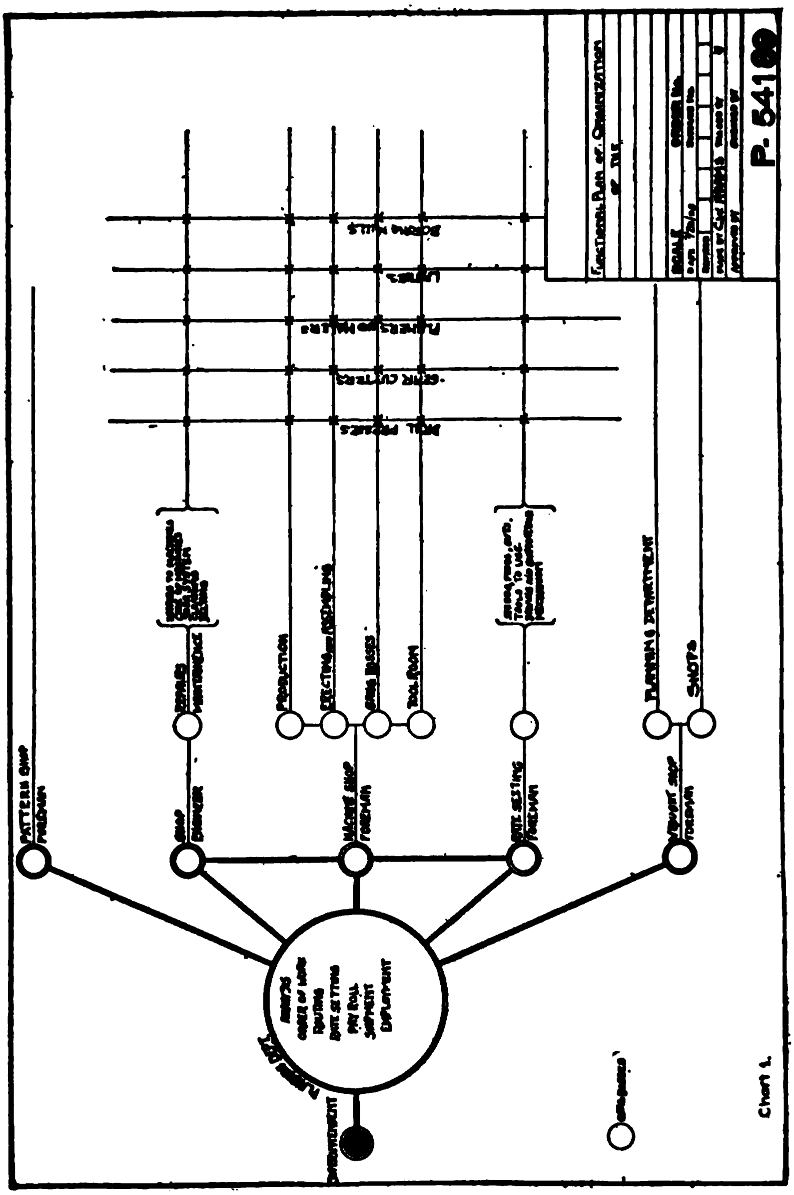

PATTERN SHOP FOREMAN
SHOP ENGINEER
MACHINE SHOP FOREMAN
RATE SETTING FOREMAN
PRODUCTION
TOOL ROOM
PLANNING DEPARTMENT
SHOPS
DRILL PRESSES
GEAR CUTTERS
LATHES
BORING MILLS
Chart I.

CHART I.

The first lecture on scientific management that I attended taught me that it must be " thus and so," and that only a limited few, four men, as I recollect, in this whole country, were thoroughly competent properly and successfully to initiate any company into the secret rites of this society. This was also impressed on me at some of the shops this summer. I have learned, however, that a real manager at the head of the system is the secret of ultimate success. The form of system, if there is a well-formed plan behind it, will be a gradual evolution depending upon the necessities of the plant. The system in itself cannot produce results with an incompetent personnel, whereas a manager of very high efficiency assisted by a competent staff will inevitably develop the most suitable system. This efficiency and competency must, however, be of a superlative order.

This is not intended to criticize scientific management or any particular system, but only to emphasize the point that the manager is the first requisite, that success is impossible if the manager is not mentally and temperamentally fitted to the work.

The Planning Department Personnel. — This consists of —

Planning department foreman,
Piece work and time study clerk,
Route clerk,
Rate setting clerk,
Order of work clerk.
Production and shipping clerk,
Balance of stores clerk,

and a number of clerks and assistants.

Planning Department Foreman. — The head of this planning department might be called the Planning Department Foreman. His function is to develop coördination between the different parts of the planning department, and between this department as a whole and the shops, in such manner as to facilitate production. He decides all shop and planning department questions which do not require the superintendent's decision. He is in effect an assistant superintendent, and general planning room and shop foreman.

Piece Work and Time Study Clerk. — This clerk does not fit into the routine of the planning room, as he has nothing to do with routing or handling orders as they go through. His functions are solely constructive. His principal duty is to superintend and extend the piece work system in the plant. To this end he takes time studies from time to time, is continually tabulating data to simplify rating, constructs slide rules for new machines, and any other slide rules from the master slide rules, decides questions concerning piece work, as for example, failure of a man to make an established standard time, etc. He is very essential to the system.

The functions of the remainder of the planning room clerks will be shown later as an order is followed through the department.

The clerks and assistants mentioned are:

Clerk at issue window, issues the blue prints and instruction cards.

Assistant to rate setting clerk.

Assistant to order of work clerk.

Assistant to production clerk.

Three stenographers to typewrite orders, bills of material, master time cards, etc.

Two boys to sort cards by operations, make out stores and worked material issues slips, etc.

Two boys at hectograph.

One boy to assist shipping clerk.

These clerks and assistants are all boys, who receive comparatively low wages.

General

All men in the planning department except stenographers and boys, that is, all having important duties, have come from the shops. They are practical shopmen who have developed into experts at their present positions. The value of their knowledge of shop methods is obvious, in fact in most instances this knowledge is imperative. Furthermore these men are expert not only at their own billets but in all cases are conversant with the work of the others. The system provides for progressive promotion throughout, which produces a versatility among the planning room force, tending towards coördination.

The Shops

(*a*) At the head of the *machine shop*, designated as D. M., is the machine shop foreman. Under him are the (1) gang bosses, who supervise groups of men, (2) the tool room, (3) the erecting and assembling gangs. Under the gang bosses are the workmen in groups.

(*b*) The *wrought* shop, designated as D. W., is under the wrought shop foreman. He has three separate groups under him, being, (1) contract work gangs, who require practically no supervision, (2) piece work gangs, such as riveters, who require little supervision, and (3) workmen on day work.

(*c*) The *pattern shop*, designated as D. P., is under the pattern shop foreman, who handles the men direct.

The various foremen have supervision over the machine tools in their shops.

(*d*) The *shop engineer* has two different functions:

1. The repair and maintenance of buildings. He performs any engineering work required about the plant due to alterations or extensions, and generally is responsible for the condition of the plant as the civil engineer of the establishment.

2. The repair and care of the machinery of the plant, including belting and shafts. He issues all specifications for new machinery, designs jigs and special fixtures, etc.

There is an assistant to the shop engineer.

The wrought shop has its own planning department. This consists of but three men. Most of the preliminary work previous to actual routing is done in the machine shop planning department; such preliminary work is copying bills of material, initial routing of materials from source to shop destination, etc. The wrought shop routing is much simpler than that of the machine shop, because a number of items, which may cover pages of the bill of material, are routed through together, the same being assembled making one division, such as a hopper, casing, etc.

Operation of the System

It is intended to show the routine from the receipt of an order until the shipment of the finished material, and later the cost keeping methods in the same manner. The charts should be followed closely with the text. The *raison d'etre* of a comprehensive cost keeping analysis is its close alliance to efficient and economical production. Without accurate cost keeping it is impossible to get a correct analysis of the business.

Without a correct analysis the weak spots cannot be located with certainty, and we are left groping for our troubles and applying the remedies much as a horse doctor would treat a child. Cost keeping on jobs serves as a clinic by which we get information on treatment for future jobs.

Credit and Estimate Departments

An order from a customer may be preceded by a request for an estimate, in which case it is referred to the estimate department. Copies of estimates furnished to customers are filed in this department.

The function of the credit department is to investigate the credit of customers before making contracts.

Classes of Orders

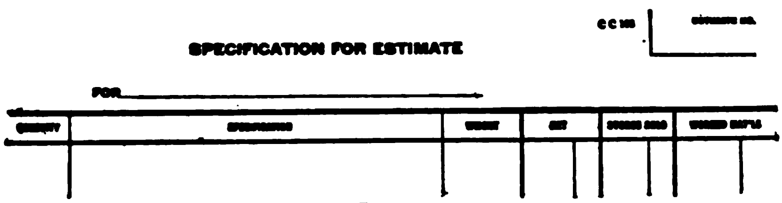
For convenience of handling in the planning department and shops, job orders are divided into five classes. They are:

1. Engineering orders, which are orders that require new designing, or engineering work. In this case the order number is preceded by a " W " to identify it. This class of order is the closest analogy to those received in a navy yard, so it is treated at length later.

2. Regular orders, which are orders that do not need new designs as they are for articles already standardized. These can be sent through direct from the order department to the planning department and routed from the original order. These orders include orders for repairs of small parts, and even small orders requiring new designs, where the design can be made by sketch in

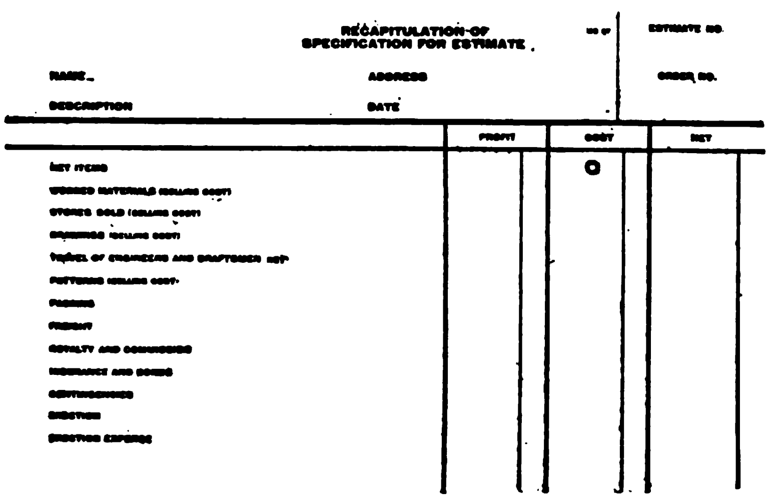
the order department. The order number in this case is preceded by an "R."

3. Silent orders, which are orders for silent gears and chain. These are in effect regular orders in their routine handling. The order number is preceded by a "C." This class of work is a


SPECIFICATION FOR ESTIMATE

FOR

Form 1.


RECAPITULATION OF SPECIFICATION FOR ESTIMATE

ESTIMATE NO.

ADDRESS

ORDER NO.

DATE

PROFIT

COST

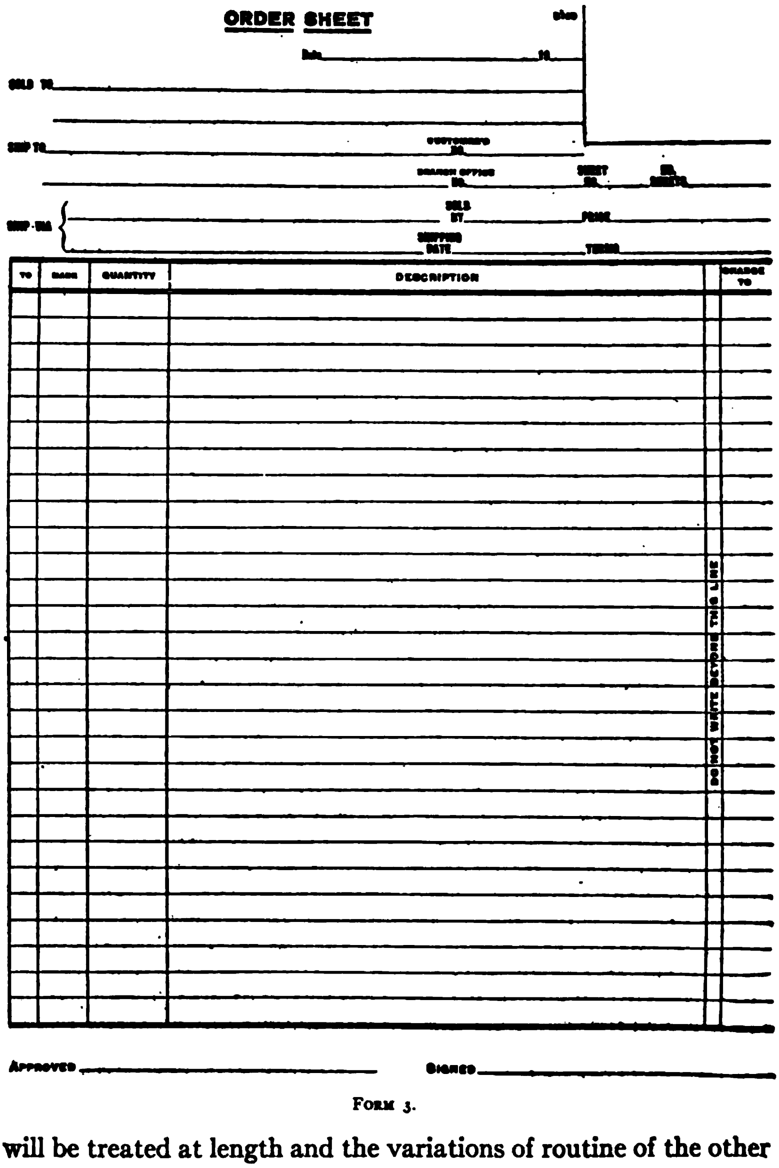
NET

Form 2.

specialty of the plant and, a separate account being desired for the class, a separate means of identifying the order is furnished by the prefixed letter.

4. Worked material orders for stores. These orders are for the manufacture of standard articles to place in the stock of the storeroom. They do not emanate from the contract department, as do the previous three classes of orders, but from the balance of stores clerk, as a requisition. Approval by the superintendent makes this requisition an order. The order number is preceded by a "Y."

The engineering "W" order, being the most comprehensive in its routine, and being most analogous to navy yard work,


ORDER SHEET

QUANTITY

DESCRIPTION

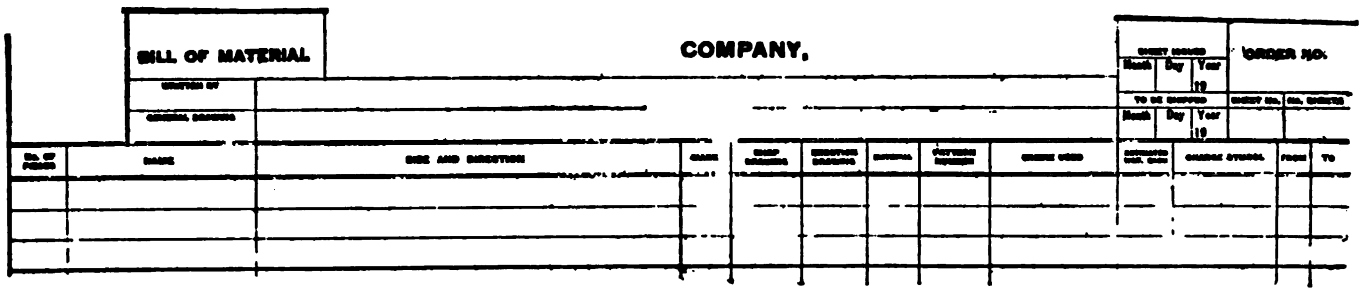
DO NOT WRITE BEYOND THIS LINE

APPROVED

SIGNED

FORM 3.

will be treated at length and the variations of routine of the other orders will be pointed out later. The forms used are numbered



FORMS 4, 5. — Form 4 is a rough form printed on manila paper. Form 5 is a smooth form printed in hectograph ink on white paper.

serially. In many cases the functions of any particular clerk or the data involved in a form will be explained later in the text to avoid undue digression from the main routine of the order.

In most cases of an engineering order "W" an estimate is requested. In these cases Forms 1 and 2 (serial numbers) are used to make up the estimate, and are filed in the estimate department.

COPYING ORDER

CHARGE TO ____________

PHOTOGRAPHIC DEPARTMENT—PLEASE MAKE THE FOLLOWING

THE WRITER SHOULD STATE IF BLUE PRINTS, BLUE LINE PRINTS OR BROWN PRINTS ARE REQUIRED

MONTH	DAY	YEAR
		19

PRINTS				BILL OF MATERIAL COPIES		
QUANTITY	DRAWING NUMBER	QUANTITY	DRAWING NUMBER	EXTRA COPIES	SHEET NUMBER	SHIPPING NUMBER

REMARKS

TOTAL NUMBER OF PRINTS	TOTAL NUMBER OF SQUARE FEET	SIGNED

FORM 6. — For manila paper.

ment. Data for making up the estimate is obtained from parts of previous similar orders, from stores and worked material cost prices, and from many other sources. This work is preliminary to the receipt of an order.

ENGINEERING ORDER

(Chart II to be read concurrently.)

Upon receipt in the contract department of an order from a customer, if it cannot be handled as a regular order it is sent to the engineering department of the contract department. The customer's order is here transferred to Form 3 (B126) and sent to the drafting room where necessary drawings are made.

Drafting Room. — This department, designated by symbol D. D. (department drawing) with a personnel of about 15% of the total, prepares all drawings for this plant. The personnel consists of one chief draftsman, with an assistant chief draftsman, and a number of boss draftsmen. The remaining draftsmen are

REQUISITIONER

REQUISITION

No.

TAG NUMBER

No. P______

THIS NUMBER MUST APPEAR ON BILL AND ON ALL PACKAGES CONSIGNED US ON THIS ORDER.

PLEASE FURNISH MATERIAL PER THIS ORDER SENDING SHIPPING RECEIPT TO US ON DATE OF SHIPMENT.

SHIPPING DIRECTIONS

MARK EACH PACKAGE

UNLESS OTHERWISE NOTED

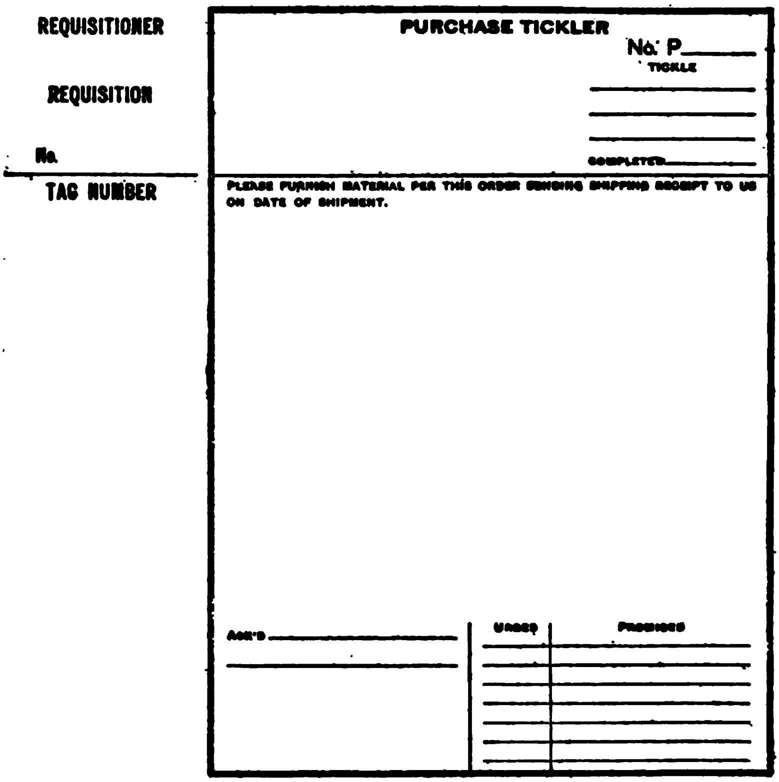
COMPANY

PURCHASING AGENT

FORM 7. — This form is in quintuplicate on different colored sheets and Tickler Form 7a.

divided up into groups of three draftsmen, one group under each boss. When an order reaches this department it is turned over to one or more bosses, depending upon the size of the order. These bosses with their assistants prepare the necessary drawings. The chief draftsman or his assistant gives necessary instructions and from time to time furnishes necessary information or settles any engineering point involved and, in general, supervises the work.

As the drawings progress, rough bills of material, Form 4 (D. D. 15) are written concurrently. The bills of material contain full description of every part of the job, with all necessary



Form 74. — Tickler.

dimensions to manufacture such parts. These parts are numbered consecutively (in column "Mark"), the reason for which will appear later. All columns of Form 4 except the last three are filled out in this department. In most cases many sheets of Form 4 are required for one order.

As the rough bills of material are completed they are typewritten in hectograph ink on Form 5 (D. D. 14), which is printed in the same ink and the smooth copies of bills of material, Form 5, are sent to the planning department, the rough copy, Form 4, being retained on file in D. D. Tracings and the necessary blue prints are made from the drawings. The prints are made by the photographic department on order, Form 6, of the chief draftsman. The tracings are filed in the vaults, the drawings go to the route clerk to aid routing.

Planning Department

The smooth bill of material is received in this department by the balance of stores clerk, who fills out the next to last column. This shows the source of the material to be used for each item, according to the following symbols:

S — From storeroom.
W — Worked material from storeroom.
F — Foundry, castings.
P — Purchase department, on purchase order.
S° — Stock order.
Y — Made on Y order.

In the last case the serial number of the " Y " order follows the symbol " Y."

From the balance of stores clerk the bill of material goes to the route clerk, who fills out the last column, showing destination of the material to be used for each item by the following symbols:

D. M. — Machine shop.
D. W. — Wrought shop.
D. P. — Pattern shop.
C. W. — Shipping room.
D. — To customer direct.

All the notations are made with copy pencil. The smooth bill of material is now sent to the purchase department, where purchase orders, Form 7 (B1), are made for all articles marked " P," purchase, in next to last column. This purchase order is made out in quintuplicate with a tickler for file in the purchase department. The use of the tickler will be explained later. The various copies of Form 7 are distributed as follows:

Original — to agent from whom purchase is made.

Two copies — filed in purchase department, one numerically and one alphabetically.

One copy — to receiving room.

One copy — to balance of stores clerk.

One copy — to auditor.

Tickler — filed in purchase department tickler.

The purchase department enters the purchase order number in copy pencil on the bill of material opposite the letter signifying that the material is to be purchased. This is done so that the various departments can refer to the material by purchase order number when looking up material due, etc.

The smooth bill of material is now returned to the planning department, where a number of hectograph copies are made to be distributed as follows:

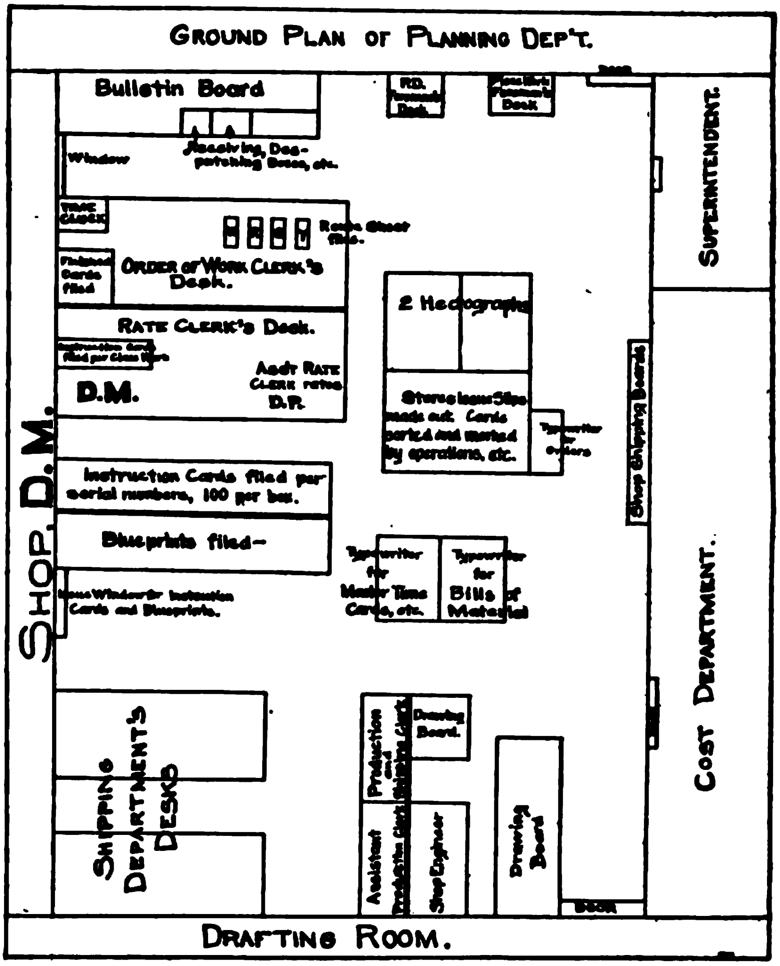
D. M. Route clerk.
D. W. Route clerk.
D. M. Inspector.
D. W. Inspector.
Cost department.
Shipping room, symbol C. W.
Production clerk.
Foundry.
Drawing room.
Main or erection-floor boss.
Planning room.

Obviously if there is no foundry or wrought shop work indicated on the bill of material this copy is omitted. The original bill of material is now returned to file D. D. (drafting room). Form 8 (copy D. D. 14) shows a copy of the 18th sheet of bill of material for order # W3248. This is the copy to the D. M. route clerk.

Items marked in column " to," as D. M. (last column), require machine shop work, therefore are handled by the D. M. route clerk.

D. M. Route Clerk. — Items marked A235, A239, A245, A249, and A250 are routed on route sheet Form 9 (AP109) as follows:

Item A235 calls for (Form 8) one shaft 2 7/16″ diameter, 3′ 10″ long, plain. This shafting is carried in stock in quantity. It is routed on the route sheet, Form 9 (AP109), in first column



ARRANGEMENT OF PLANNING DEPARTMENT.

as follows: operation 1, C — cut off, on lathe 14L; operation 2, I — inspect; operation 3, C. W. — move to shipping room.

Item 239 calls for (Form 8) a sprocket # 103 (# 103 refers to a standard pattern) having 23½″ pitch diameter and 24 teeth.

The casting is made cored to 2" diameter; hub dimensions 5" × 2" × 5"; two set screws. It is routed in column 2, Form

BILL OF MATERIAL T.E.M. — W3249 #18

W BERTRAM — BEAUFORT FISH SCRAP AND OIL CO.

9 | 5 | 11 — ORDER NO. W 3249 — 18

	FLIGHT	CONVEYOR TO DRYER										
	CHAIN											
	STRAND #103 CHAIN	75'0" LG. WITH F-2 ATT EVERY 7TH LINK	R-230		P 27552						S	CW
		COMPLETE WITH COUPLER										
	TAKE UP SHAFT											
1	SHAFT	2-7/16" X 3' 10" PLAIN	235	P27532							S	DM
2	TAKE UPS	2-7/16" X 12" STYLE "B"- TAP FOR #2 G.C.	236								W	CW
2	GREASE CUPS	#2 L.B.	237								S	CW
2	SAFETY COLLARS	2-7/16"	238								W	CW
1	SPKT # 103	H.B.S. 5" X 2" TWR 5"	239								F	DM
	23-1/2" P.D. 24T	BORE 2-7/16" 235										
	DRIVE SHAFT	30 R.P.M.										
1	SHAFT	2-7/16" X 3' 9-1/2" K.S. 6" PL16-5/8"	245	P27532							S	DM
		K.S. 6" PL 16-7/8"										
2	KEYS	5/8" X 6"	246								W	DM
2	ANGLE BEARINGS	2-7/16" BASE GREASE CUP	247								W	ZW
2	GREASE CUPS	#2 L.B.	248								S	ZW
1	SPKT #103	H.B.S. 5" X 2" TWR 5"	249								F	DM
	23-1/2" P.D. 24T	BORE 2-7/16" K.S. 236										
1	BEVEL GEAR											
	19.51 P.D. 48T	H.O.D. 5" X 1-3/8" FIN TO 4" BACKING										
	1-1/4" P 3-3/16" F	TWR 5-1/4" BORE 2-7/16" K.S.&S.S.	250				61 P8048				F	DM

FORM 8. — This is Form 5 filled out for part of an engineering order.

9, as follows: G — grind (teeth); B — bore (hub), on lathe 12 (L-12); S. S. — drill and tap for set screws on drill press 17 (D-17); I — inspect; C. W. — to shipping room.

Item A245 calls for one shaft 2 7/16" diameter 319½" long, with two key seats 6" long with location of key seats given. It is routed as follows: C — cut off, at lathe 14L; M — mill, at 4M, for key seat; A — assemble at key-seat bench; I — inspect; C. W. — to shipping room. The "assemble" referred to consists of assembling items 4 and 5 on shaft, item Mark A245.

Item A249 calls for the same as A239 except a key seat is cut at 2K and the sprocket then goes to key seat bench to be assembled on A245.

Item A250 (Form 8) calls for one bevel gear, 19.51" pitch diameter, 49 teeth, hub dimension given; to be bored to 2 7/16" to fit shaft A249, key seated and two set screws. It is routed, last item, Form 9, as follows: Bore at 12L; face hub at 11L; key seat at 2K; drill and tap for set screws at 17D; clean teeth on main floor (necessary when teeth are cast); assemble on A245 at key seat bench; inspect; shipping room.

Form 9a shows most of the symbols used in routing. If blue prints were used by the route clerk to aid routing, they are now filed at the issue window for issue to the workmen.

The route sheet is clipped to the copy of bill of material and sent to a copy boy who prepares master time cards for each item,

A.	Assemble.	SS.	Set screw.
B.	Bore.	SAW.	Saw.
BB.	Babbitt.	M.	Mill.
C.	Cut.	CP.	Chip.
CT.	Cut teeth.	FT.	Fit.
F.	Face.	AD.	Assemble and drill.
P-F.	Pin flanges.	Rm.	Ream.
S-F.	Shrink flanges.	P.	Plane.
T-F.	Turn flanges.	Tp.	Tap.
A-F.	Assemble flanges.	OG.	Oil groove.
T.	Turn.	G.	Grind.
RB.	Rough bore.	I.	Inspect.
FB.	Finish bore.	CB.	Counterbore.
R-T.	Rough turn.	FT-JWS.	Fit jaws.
F-T.	Finish turn.	CL.	Clean.
D.	Drill.	Th.	Thread.
L.	Layout.	Cen.	Center.
SP.	Split.	Csk.	Countersunk.
K.	Key seat.		

ROUTE SHEET

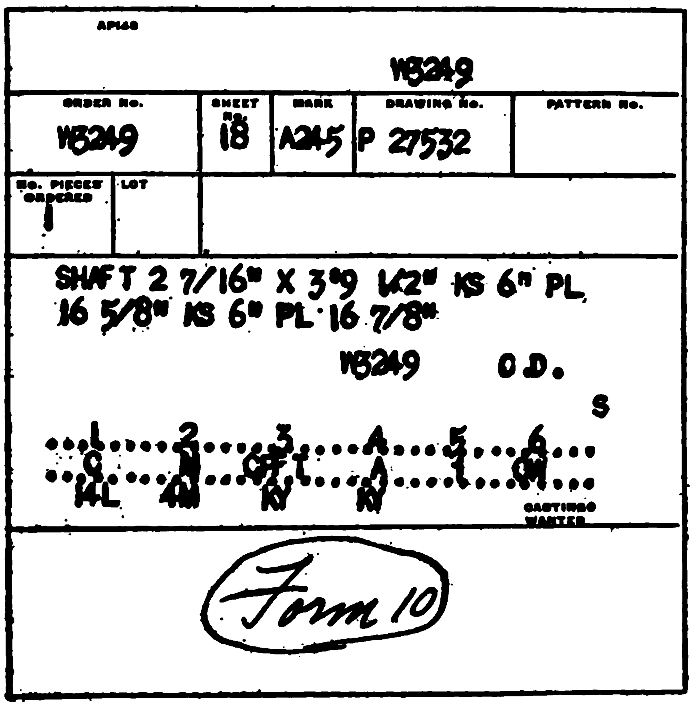
SHIPPING DATE ____

SHIPPING ORDER NO.	SHEET NO.
W3249	18

	Card 1		Card 2		Card 3		Card 4		Card 5		Card 6	
NO. OF PIECES	1		1		1		1		1			
MARK	A235		A239		A245		A249		A251			
CHARGE SYMBOL												
DESCRIPTION	Shaft 2 7/8" x 3'-10		23½" #103		Shaft 2 7/8" x 3'-9½		23½" — #102		19.51" Bevel			
	MATERIAL RECEIVED		MATERIAL RECEIVED		MATERIAL RECEIVED		MATERIAL RECEIVED		MATERIAL RECEIVED		MATERIAL RECEIVED	
1	14L	C		G	14L	C		G	12L	B		
2		I	12L	B	4R	M	12L	B	11L	F		
3		CW	17D	SS	Ky	Cp-Ft	2K	K	2K	K		
4				I	Ky	A	17D	SS	17D	SS		
5				CW		I		Ky	MF	Clean		
6						CW		I		Ky		
7								CW				
8										I		
9										CW		
10												
11		SEP 11 1911										
12												

Form 9.

showing item No., No. of pieces ordered, description, source of material and operation to perform. Form 10 (AP148) shows



AP148

W3249

ORDER NO. W3249 | SHEET NO. 18 | MARK A245 | DRAWING NO. P 27532 | PATTERN NO.

NO. PIECES ORDERED 1 | LOT

SHAFT 2 7/16" X 3'9 1/2" KS 6" PL 16 5/8" KS 6" PL 16 7/8"

W3249 O.D.

S

1 2 3 4 5 6

CASTINGS WANTED

Form 10

Form 10. — Master Time Card.

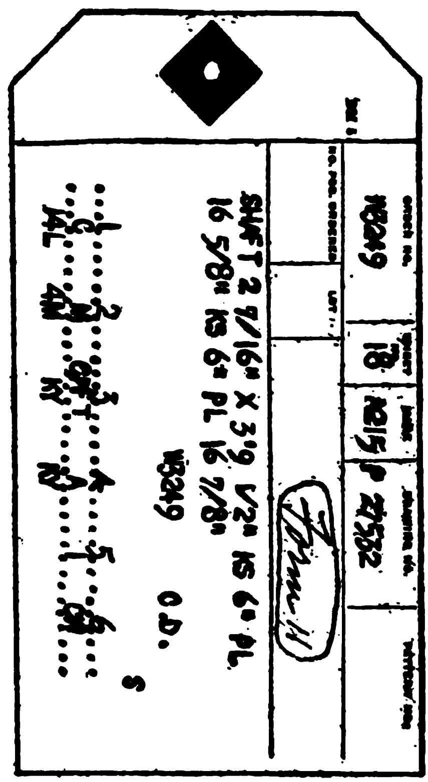
the master time card for item A245. This is made of hectograph ink and a copy boy makes the following copies:

1 route tag.................. Form 11 (DM5).
1 stores issue................ Form 12 (CS103).

and for each operation,

Group { 1 time card.................. Form 13 (DM148).
1 shop card.................. Form 14 (DM148A).
1 move card................. Form 15 (DM148A).

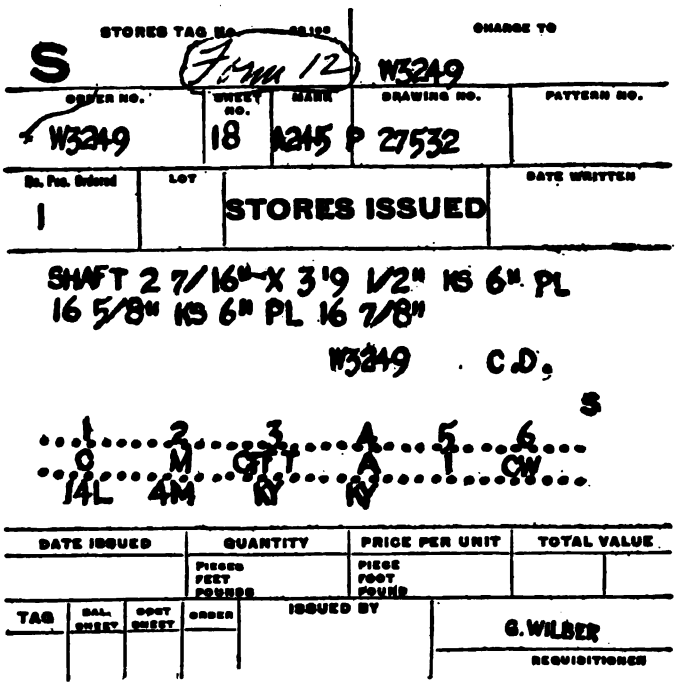
The required number of cards being made out, the master time card is destroyed. The cards are sorted and clipped into groups as above, one group for each operation. The operations are numbered in pencil. The route tag and stores issue slip are clipped to the cards of the first operation. In the order under consideration operations 1, 2 and 4 do not require shop copies, as these machines work on summary work, which will be explained later. Also operations 3 and 4 do not require move cards, because operations 4 and 5 are performed at the same place as operation 3.



FORM 11. — Route Tag.

After the necessary cards are made out the route sheet is filed at the order of work clerk's desk, where a record of the progress of work is kept. The copy of bill of material goes to a clerk who makes out the necessary stores issue and worked material issue slips for such items as are drawn from storeroom to go to C. W. (shipping room). Referring to Form 8, items A230, A237 and A248 are stores issued to C. W., and A236, A238 and A247 are worked materials issued to C. W. The former are made out on Form 12 and the latter on 17.

The forms for stores issue and worked material issue (for articles whose destination is C. W.) are sent to the shipping room


S
STORES TAG NO.
Form 12
CHARGE TO
W3249
ORDER NO. W3249
SHEET NO. 18
MARK A245
DRAWING NO. P 27532
PATTERN NO.
No. Pcs. Ordered 1
LOT
STORES ISSUED
DATE WRITTEN
SHAFT 2 7/16" X 3'9 1/2" KS 6" PL
16 5/8" KS 6" PL 16 7/8"
W3249 . C.D.
S
1 2 3 4 5 6
O M QTY A 1 CW
14L 4M N N
DATE ISSUED
QUANTITY PIECES FEET POUNDS
PRICE PER UNIT PIECE FOOT POUND
TOTAL VALUE
TAG
BAL. SHEET
COST SHEET
ORDER
ISSUED BY
G. WILBER
REQUISITIONER

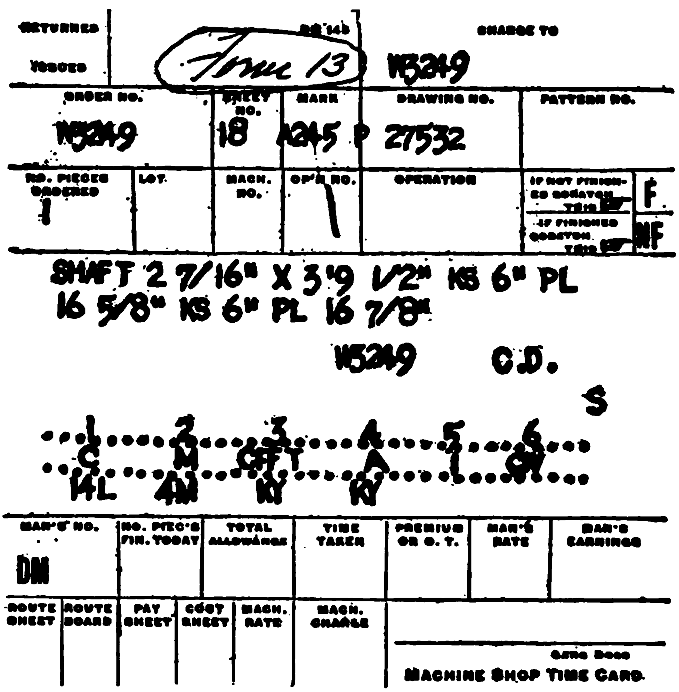
FORM 12. — Stores Issue Slip.

C. W.; and when the articles are desired for shipment the forms are sent to the storeroom, where they are exchanged for the desired articles.

The storekeeper, after making the necessary memorandum of issue on his tag (see bottom of Form 12), sends the slips to the cost department, where the issue is entered on the balance of stores sheet and cost sheet.

In the case of all shafting items, except plain shaft, a line sketch, Form 18, showing position and character of key seats, accompanies the time card for the milling operation.

All time cards, together with shop copy and move cards, which are clipped to them, go to the rate clerk to be rated. This consists in posting on the back of the time card the necessary data *re* time and pay (explained later), the tools, cuts, feeds, speeds, etc., instruction card and drawing numbers. Some of these are shown on the time cards, front and back, of A245 operation 1. The tags are sent to the receiving room and secured to the material called for by the stores issue slip, or if the material is not from


RETURNED
ISSUED
CHARGE TO
Form 13
N5249
ORDER NO. N5249
SHEET NO. 18
MARK A245
DRAWING NO. 27532
PATTERN NO.
NO. PIECES ORDERED 1
LOT
MACH. NO.
OP'N NO. 1
OPERATION
F
NF
SHAFT 2 7/16" X 3'9 1/2" KS 6" PL
16 5/8" KS 6" PL 16 7/8"
N5249 C.D.
S
MAN'S NO. DM
NO. PIEC'S FIN. TODAY
TOTAL ALLOWANCE
TIME TAKEN
PREMIUM OR D. T.
MAN'S RATE
MAN'S EARNINGS
ROUTE SHEET
ROUTE BOARD
PAY SHEET
COST SHEET
MACH. RATE
MACH. CHARGE
MACHINE SHOP TIME CARD

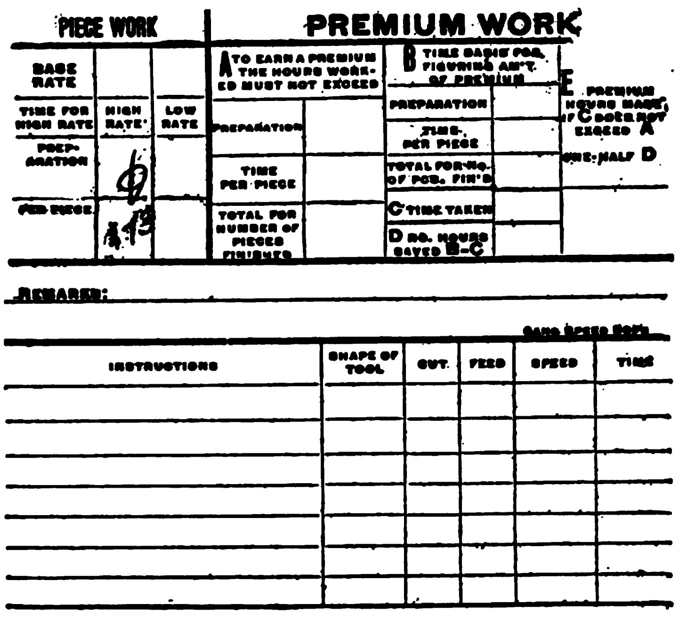
FORM 13. — Time Card.

the store then the tag is secured to the material upon receipt. In the case of A239, A249 and A250, the foundry tag is destroyed when the casting is received and the route tag is substituted. In the case of A235 and A245 slips of stores issued, Form 12, are sent to the storeroom, and tags, Form 11, accompanying them are attached to shafting as soon as it is cut to length. Theoretically the tag is attached before the material leaves the storeroom.

In the meantime the slips for all operations have been placed in the receiving box. As soon as the material is received in the storeroom or receiving room and tagged a notification is sent to the order of work clerk, who posts the time and move cards of the first operation on the bulletin board, and the shop copy on the shop bulletin board, if the machine designated for the first operation has a shop board.

The cards for all other operations are placed in the despatching box, in sequence by order numbers.

On the bulletin board are two sets of hooks for each machine. The cards on the upper hook represent jobs on that machine

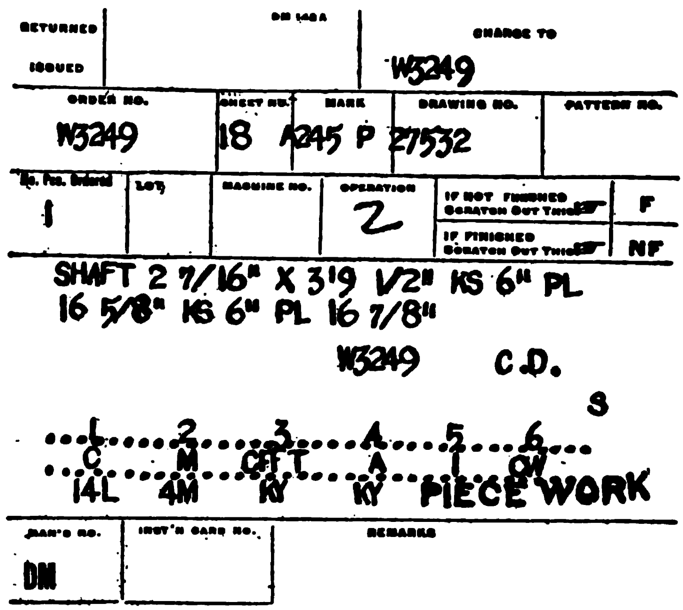


FORM 13. — Reverse of Time Card.

arranged in the sequence in which they are to be performed. The top card represents the job that the man is working on. Cards on the lower hook represent jobs at the machine, but the sequence in which the jobs are to be performed has not been determined. The precedence of the slips on the upper hook is regulated by the order of work clerk to be in accordance with the order of shipping dates of the various jobs as obtained from the shipping boards in the planning room.

The material is moved from the receiving room to the machine shown on the tag under first operation.

The receipt of material in the shop signifies to the order of work clerk that the material is at the machine, and the order in which it is to be done is now arranged; when the man has completed one job the tool boy goes to the time card window, turns



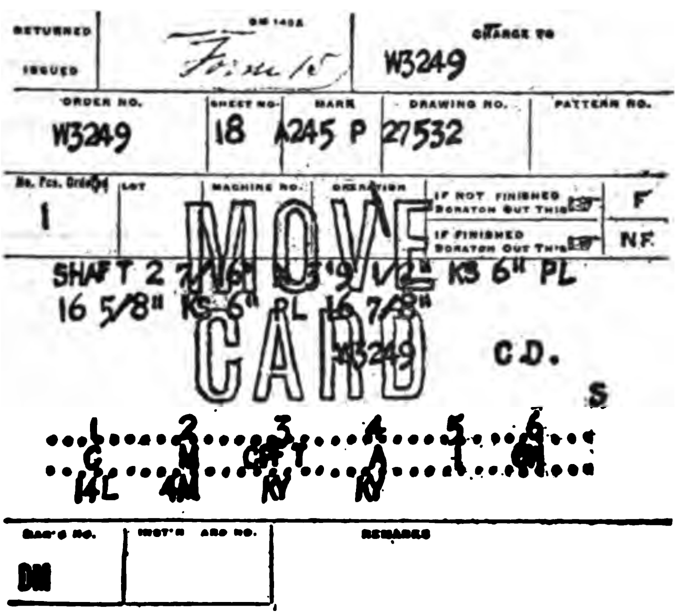
MACH. SHOP DUPLICATE TIME CARD

FORM 14.

in the card for the finished job and receives a card for the next job, posted on the planning room bulletin board, a duplicate of which shows on the machine bulletin board in the shop.

The boy also goes to the issue window for instruction card and drawing, if such are designated. Any special tools required are also drawn for the man by the tool boy on the man's check. When the time card is issued the time is stamped in hours and hundredths of hours (upper left corner) " out " The job being completed the card is turned in to the order of work clerk and the time again stamped on the card (upper left corner) " in." The difference between the two is the time of the job.

The shop bulletin board has a number of hooks in a vertical row for the jobs ahead of the machine so a man can see all of them. As soon as the operation is completed the move card is taken from the planning room bulletin board and given to the move gang, who move the material to the machine designated

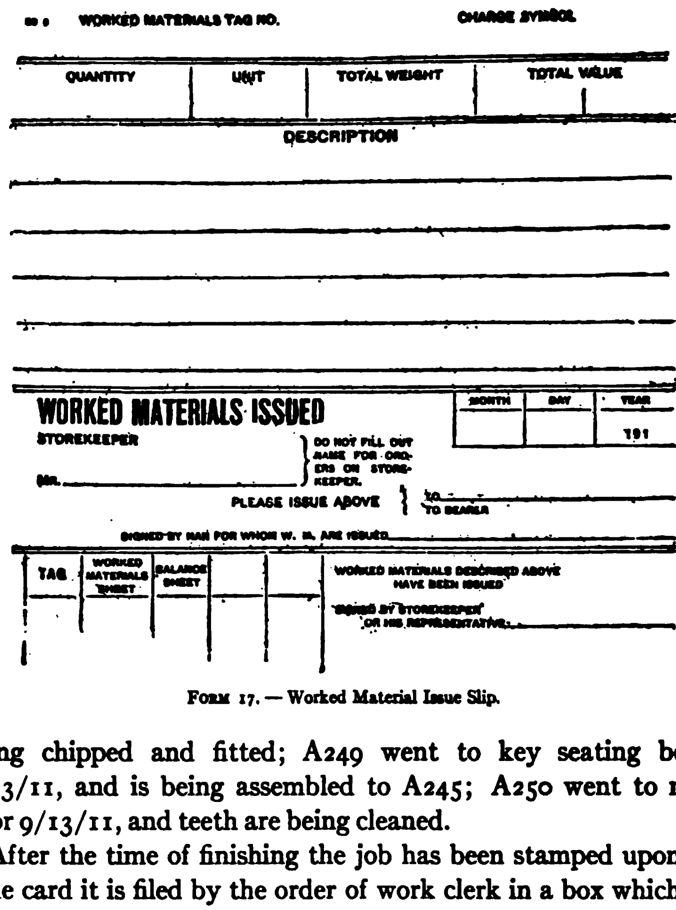


MACH. SHOP DUPLICATE TIME CARD

FORM 15. — Move Card.

on tag for the second operation. At the same time cards for the second operation are posted, as were the previous ones, and the same routine followed. When the work is moved the move card is returned to the order of work clerk, who checks the operation as completed on the route sheet (see Form 9) by drawing a blue vertical line opposite the operation concerned and noting the date. The move card is then destroyed.

When all operations are completed, and after the work is inspected in the shipping room, Form 19 (AP7) is made out and sent to the order of work clerk. The blue line on the route sheet is then extended to the bottom of the sheet and the date of inspection is stamped on the route sheet. The order of work clerk initials under column " Route Sheet " on Form 19. The route sheet under consideration shows state of work on sheet to be as follows: A235 finished and inspected in C. W. 9/12/11; A239 ready for inspection; A245 went to key seating bench 9/12/11,


WORKED MATERIALS TAG NO. CHARGE SYMBOL

QUANTITY | UNIT | TOTAL WEIGHT | TOTAL VALUE

DESCRIPTION

WORKED MATERIALS ISSUED

STOREKEEPER

MR. DO NOT FILL OUT NAME FOR ORDERS ON STOREKEEPER.

MONTH | DAY | YEAR 191

PLEASE ISSUE ABOVE TO TO BEARER

SIGNED BY MAN FOR WHOM W. M. ARE ISSUED

TAG | WORKED MATERIALS SHEET | BALANCE SHEET

WORKED MATERIALS DESCRIBED ABOVE HAVE BEEN ISSUED

SIGNED BY STOREKEEPER OR HIS REPRESENTATIVE

Form 17. — Worked Material Issue Slip.

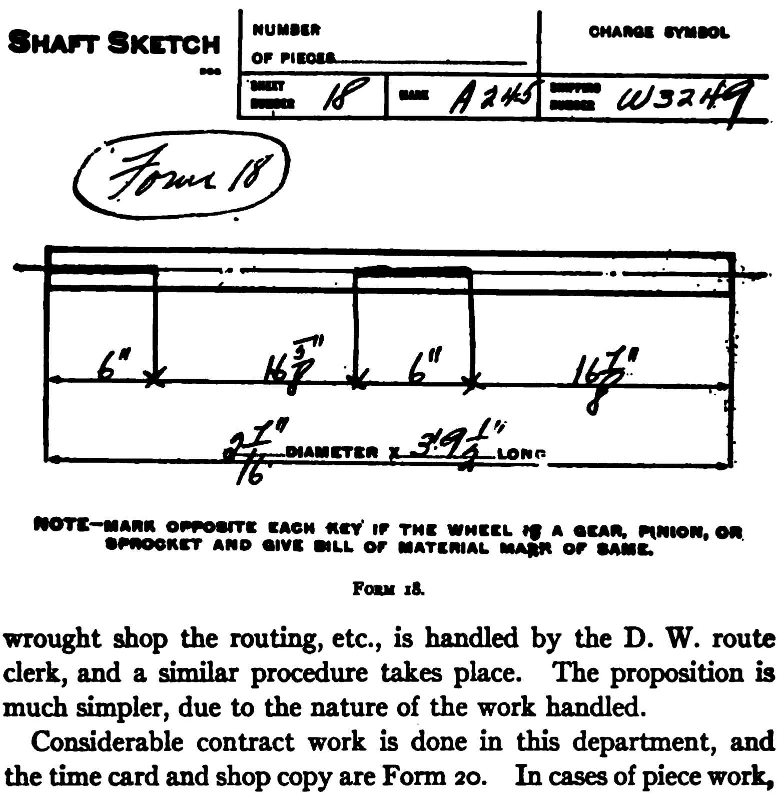
being chipped and fitted; A249 went to key seating bench 9/13/11, and is being assembled to A245; A250 went to main floor 9/13/11, and teeth are being cleaned.

After the time of finishing the job has been stamped upon the time card it is filed by the order of work clerk in a box which has compartments for the different classes of machines. These cards are turned into the cost department daily, and the man receives a daily statement of his earnings for the previous day.

Daily all route sheets on which all items have been completed and inspected are taken from the files and sent to the superintendent, and a notification of these jobs and sheet numbers is sent to the production clerk for his information.

When an operation is completed the shop bulletin board copy is checked and destroyed by the order of work clerk; all other slips on the board are then moved up a peg.

This is the ordinary procedure for an engineering order as illustrated by Chart II (facing page 306). In case of work in the



Form 18.

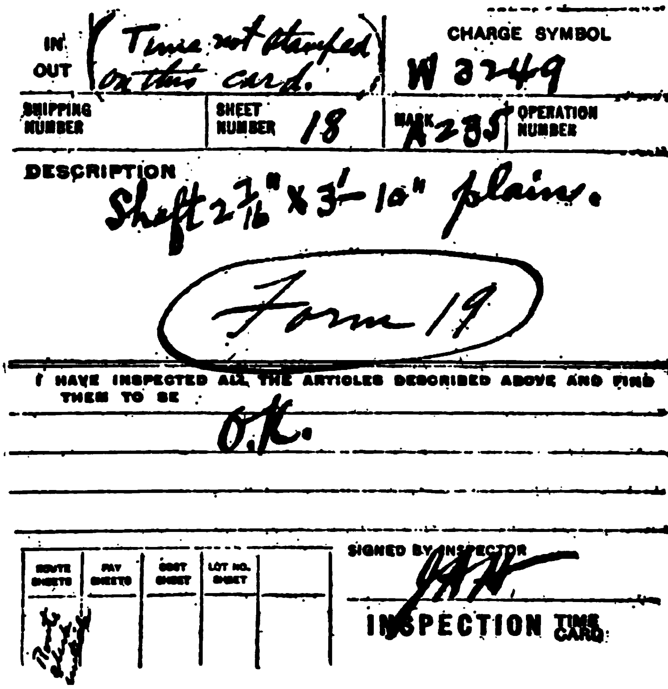
wrought shop the routing, etc., is handled by the D. W. route clerk, and a similar procedure takes place. The proposition is much simpler, due to the nature of the work handled.

Considerable contract work is done in this department, and the time card and shop copy are Form 20. In cases of piece work, premium or day work the card is similar to that used in D. M.

Classes of Work according to Pay

1. Piece work, with high and low rate.
2. Premium work.
3. Day work.
4. Contract work.

Piece Work. — The ultimate aim, in order that employer and employee may profit the maximum, is the piece work system with high and low rate. When this system is employed the workman benefits in wages by any increase of output and the company benefits by increase of production per machine. This is the perfection of sliding scale bonus. In order that piece work may be


IN / OUT (Time not stamped on this card.)
CHARGE SYMBOL W 3249
SHIPPING NUMBER
SHEET NUMBER 18
MARK K 285
OPERATION NUMBER
DESCRIPTION Shaft $2\frac{7}{16}$" x 3'-10" plain.
Form 19
I HAVE INSPECTED ALL THE ARTICLES DESCRIBED ABOVE AND FIND THEM TO BE O.K.
ROUTE SHEETS | PAY SHEETS | COST SHEET | LOT NO. SHEET
SIGNED BY INSPECTOR
INSPECTION TIME CARD

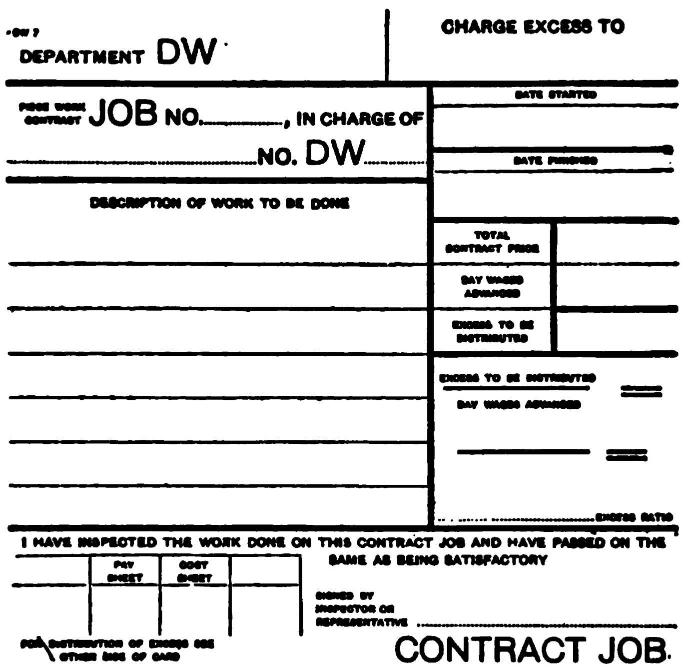
FORM 19. — Inspector's Slip.

employed the standard piece work time must be absolutely correct and fair for the average workman. The piece work rate, once established, cannot be "cut." This must always be borne in mind, as cutting of rates is invariably followed by discontent among the workmen and spells disaster to the success of the system. These standard times are being added to daily; at present there are more than 10,000 such times established here, and of course many more can be deduced from parts or combinations of parts of these. In cases where these times have been established the man is paid a certain fixed rate per finished piece, the high rate if finished under the minimum time allowed, the low rate if he exceeds this time. These high and low rates are determined from a base rate as follows:

The base rate = the average pay in the neighborhood for work on the class of machine to be operated.

High rate = 1.35 of the base rate (35% bonus).

Low rate = 5/6 × high rate (12½% bonus); but, if the man makes low rate, with the increased time the man's output


DEPARTMENT DW
CHARGE EXCESS TO
PIECE WORK / CONTRACT JOB NO. ......, IN CHARGE OF
...... NO. DW......
DATE STARTED
DATE FINISHED
DESCRIPTION OF WORK TO BE DONE
TOTAL CONTRACT PRICE
DAY WAGES ADVANCED
EXCESS TO BE DISTRIBUTED
EXCESS TO BE DISTRIBUTED
DAY WAGES ADVANCED
EXCESS RATIO
I HAVE INSPECTED THE WORK DONE ON THIS CONTRACT JOB AND HAVE PASSED ON THE SAME AS BEING SATISFACTORY
PAY SHEET
COST SHEET
SIGNED BY INSPECTOR OR REPRESENTATIVE
FOR DISTRIBUTION OF EXCESS SEE OTHER SIDE OF CARD
CONTRACT JOB.

FORM 20. — Time Card for Contract Work. In duplicate — original, white; duplicate, manila.

is lowered, and consequently his total pay is lowered. If he falls just below the time allowed he would still get a little over what he could make at straight day rate. If he runs much over the time allowed he loses considerably. However, it is very rare in this plant for a man to run over the minimum time without good reason. In case of unusually hard metal or any valid cause the man is given high rate, and in case of new men who have been employed less than six months, they get a guaranteed day rate if they fail to make high rate.

In the case of a man working at a machine which has a base rate higher than his own base rate, determined by his usual machine, he would be paid on the higher base rate basis. If a man

DW NO.	WORKMAN'S NAME	DAY WAGES ADVANCED	EXCESS DISTRIBUTION
	TOTAL DAY WAGES ADVANCED		
		TOTAL EXCESS DISTRIBUTION TO BE CHARGED	

FORM 20.— Reverse of Duplicate.

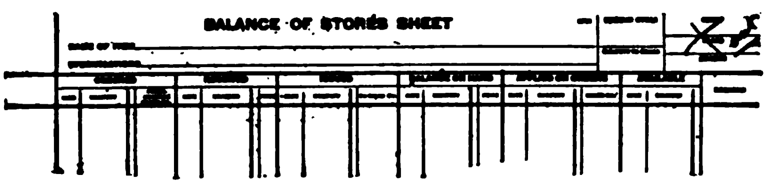
work at a machine which has a lower base rate than his own he would get the base rate of the machine + a retainer fee per hour of (his rate − the base rate).

Example. — Base rate 20 c.
High " 27c. $= 1.35 \times .20$
Low " 22½c. $= 5/6 \times .27$

If an 18 c. man work on this job he gets paid on the 20 c. base rate.

If a 22 c. man work on this job he gets paid on the 20 c. base rate, and in addition there is added to his day's earnings 2 c. per hour (called 2 c. retainer) for all his working time. The form for this will be shown later.

Premium Work. — Where a piece work rate has not been accurately established the work is placed on the premium basis. Such work is chipping and fitting, assembling wheels on shafts, etc. By this system an estimated time allowance is placed on the job. The pay is at a fixed hourly rate. If the man exceed the time allowed he is paid his hourly rate for his actual working time. If he does the job in less than the allowed time he is paid for his actual working time + ½ (the difference between the



FORM 21. — Balance of Stores Sheet.

time allowed and his actual working time). In other words, he gets a bonus of ½ the time he saves on an estimated time. This gives the fast workman a bonus over the average worker, without doing harm to the slower worker.

Day Work. — Day work is straight pay on a hourly basis. This is applied to move men, laborers, and for work on which no time can be estimated.

Contract Work. — Work is paid for under this scale as follows: A large job in the truss shop, such as assembling and riveting a tank, is farmed out to a boss workman who will have several men — say a riveting gang — under him. These men all have established day rates. A contract price is placed on the job. This price is distributed in proportion to the hourly rates of the several men. The men are paid daily as follows: Each day the men receive their daily pay according to their hourly rate until the total contract price is paid out. Should the contract be completed before the total contract price is paid out an excess remains to be distributed among the men *pro rata* on their daily rate.

Example. — Suppose a tank to be assembled and riveted, contract price $40.00.

Men employed:

Boss at $5.00 day.
Helper at 3.00 day.
Helper at 2.00 day.

If this job were completed in three days the several amounts paid to date of completion would be:

Boss	$15.00
1st helper	9.00
2d helper	6.00
	$30.00
Excess to be distributed	10.00

$$\frac{\text{Excess to be distributed}}{\text{Total days' wages paid}} = \frac{10}{30} = \frac{1}{3} = \text{excess ratio.}$$

Excess for each man.

Boss	$\frac{1}{3} \times \$15 = \$5$
1st helper	$\frac{1}{3} \times \$9 = \$3$
2d helper	$\frac{1}{3} \times \$6 = \$2$

See Form 20.

Should the men draw the total contract price before the job is completed the hourly rate is continued as long as the job is in hand. It is a rare case in which the job is not finished before this time. Cases of palpable error in under-estimating contract price are subject to readjustment.

Cases of readjustments on pay of men are very rare. Unusually hard metal making a large cutting time, clerical errors, and new men are the only causes that arise. Fairness and contentment mark the working of the system at this plant. During a seven-week period under observation but one case arose where a man got low rate on piece work.

The installation of this system was very gradual. A few of the best workmen were put on piece work, the rate on which had been very carefully established by time study. As soon as it was apparent to the other men that those on piece work were consistently making more than they could make at their day rate, request for piece work came from the men themselves.

Route Clerk. — The route clerk must be a practical shop man, thoroughly conversant with the capacities of machines and of men and with general shop practices. A tabulated form showing the capacities of the machines is originally prepared, but the route clerk must be conversant with this data to successfully route. He must place the work at the machine which will handle it most efficiently and quickly. He must be in touch with the general condition of work at the different machines so as to distribute the work to best advantage.

Often two operations can be performed simultaneously, such as boring a hub and rough turning the flange of a wheel. He must decide whether to do these as one or two operations, being governed by the work at the various machines, etc. The combinations and possible varieties of routing that pass through his hands are many, and his is a billet that requires knowledge from experience. Routing of items which are often repeated becomes almost automatic.

The route clerk keeps a card index in which he makes a memorandum of the route of any new item. This forms a ready reference for similar items, until such time as he becomes thoroughly familiar with their routing.

Many items, such as gears, etc., are standardized. Tables are prepared for all of these showing the several dimensions. In this case the item is often identified by a number, thus: 23" sprocket # 103. From the standard tables all dimensions can be obtained.

For engineering jobs the blue prints are sent to the route clerk with the B. M. This is necessary to routing, as the interrelation of parts, the dimensions, etc., are thus obtained.

Rate Setting Clerk, Instruction Cards and Drawings. — The rate setting clerk determines the class pay for a job. He places the time allowed for preparation, and per piece. Preparation time is allowed on the first piece only where the piece work is used. The base, high and low rate are also placed on the card. An omnimeter having fixed lines on the marker is employed to

BALANCE OF STORES SHEET

NAME OF ITEM: Bolts

SPECIFICATIONS: 7/8" x 3"

MINIMUM STOCK

3000

QUANTITY TO ORDER

Ordered: Date	Ordered: Quantity	Ordered: Purch. or Stock Order No.	Received: Date	Received: Quantity	Received: Price	Issued: Date	Issued: Quantity	Issued: On Order No.	Balance on Hand: Date	Balance on Hand: Quantity	Balance on Hand: Price	Applied on Orders: Date	Applied on Orders: Quantity	Applied on Orders: Order No.	Available: Date	Available: Quantity	Remarks
8.7	5000	84732														5000	
												8.8	200	W3094		4800	
			8.16	5000						5000	.06						
												8.8	700			4100	
						8.17	3	R67592		4997						4097	
						8.19	200	W3094		4797							
												8.17	3000			1097	
		Y3246	8.21	50						4847						1147	

Form 216. — Method of Keeping Balance of Stores Sheet.

determine various rates and to determine the pay per piece. The class of pay, allowed times, etc., are found from instruction cards.

REQUISITION No. 57753

DEPARTMENT ________ MONTH ____ DAY ____ 19 ____

TO THE PURCHASING AGENT:
PLEASE ORDER THE FOLLOWING FOR

TAG NUMBER	DESCRIPTION	[illegible]

WANTED, MONTH ____ DAY ____ 19 ____

SIGNED ________

STOREKEEPER'S ENDORSEMENT:
NOT IN STORES
OVER

APPROVED,

PURCHASE OF ________

F. O. B. ________ WANTED TO BE SHIPPED, MONTH ____ DAY ____ 19 ____ VIA ________

SIGNED ________

PURCHASE ORDER NO. ________ WRITTEN MONTH ____ DAY ____ 19 ____ BY ________

FORM 22. — Requisition for Stores.

Instruction Cards. — There are two sets of these cards, one filed by class of work for the rate setting clerk's use, the other filed serially for issue to the workmen. The instruction card numbers and drawing numbers are noted on the time card. When needed by the workmen they are drawn from an issue window on workmen's checks. The cut, feed, speed, machine time, etc., are placed on the time cards. These are obtained from the instruction cards, or, if unknown, can be computed by slide rules. A master slide rule is prepared for each class of machine, and slides to fit these master rules are prepared for each machine of the class.

Balance of Stores Clerk. — The principal function of the balance of stores clerk, as his name implies, is to keep a balance of

Y-ORDER

SYNOPSIS OF CONTENTS.

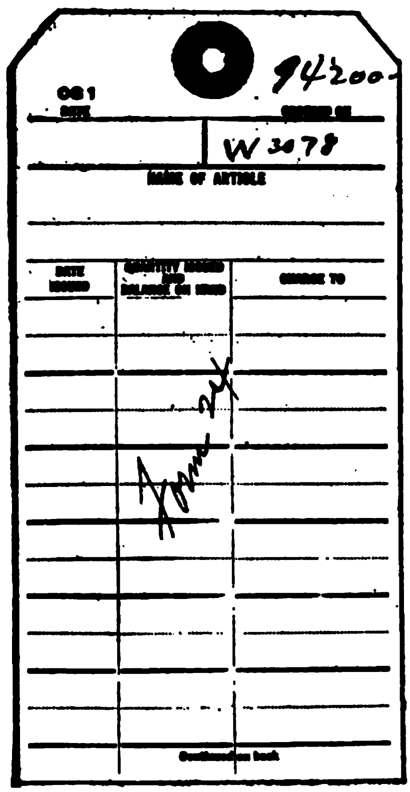
FORM 23.

the stores on hand in the storeroom. This is done on Form 21, balance of stores sheet, as follows: Each class of stores has its own sheet showing name of item, minimum stock allowed, quantity to order at one time, and columns: ordered, received, balance on hand, applied on orders, and available.

The sheet, Form 21, is kept as follows:

When stores are ordered they are entered with date, quantity and purchase order number in the first column. Upon receipt a vertical line is entered after the quantity ordered and the same quantity is entered in the second column. Stores are ordered either on requisition, Form 22, on purchase department, if for stores, or by "Y" order, Form 23, if for worked material for store. In either case the requisition or order emanates from the balance of stores clerk, when the amount available is less than the minimum stock per his balance sheet. Its approval by the superintendent is authority to purchase in the former case and for manufacture at the plant in the case of a "Y" order.

Receipts. — In the case of a purchase order, as stated previously, the receiving room is furnished with a copy of the purchase order. When the stores are received in the storeroom, a



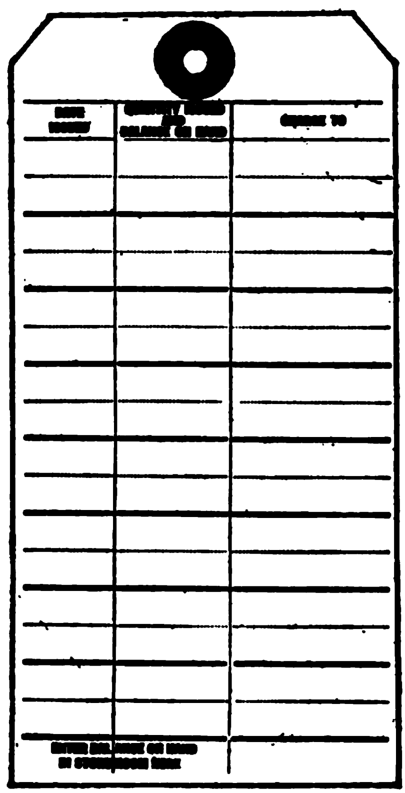
FORM 24. — Bin Tag.

notification form is sent to the balance of stores clerk and at the same time the quantity received is entered, on the bin tag, Form 24, of the receiving bin.

In the case of a " Y " order the same procedure follows, except that Form 25 is sent by the receiving room to report receipt to the balance of stores clerk.

Debits. — When a bill of material goes through the balance of stores clerk's hands and he designates origin of items as " stores " he debits under column " Applied on Orders," all such stores.

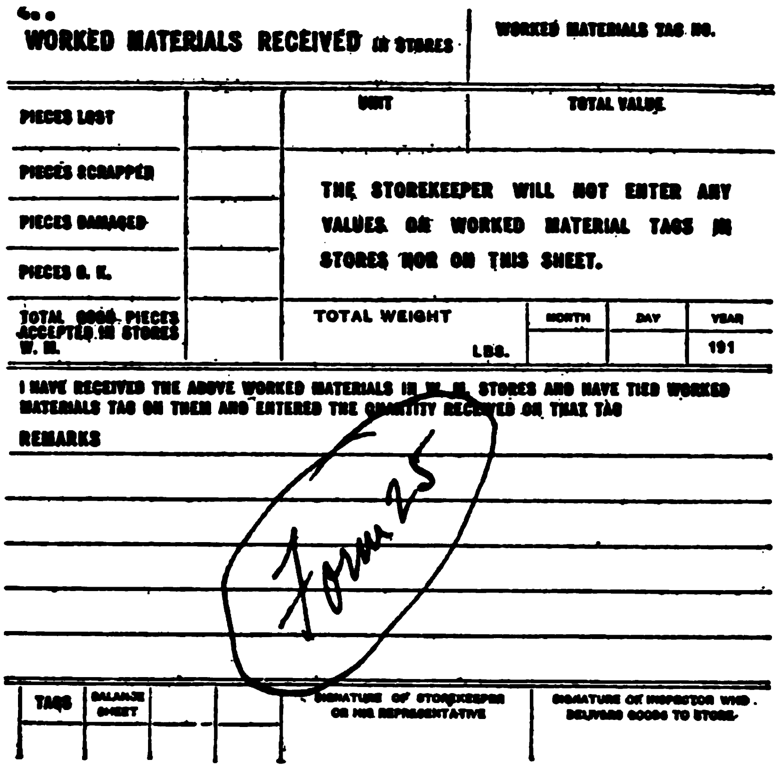
After the stores are actually drawn, that is, when he receives slips, Form 12 or 17, he debits column "Issued," enters balance on hand and draws vertical line opposite stores affected under column "Applied on Orders." When the quantity "Balance on Hand" minus quantity "Applied on Orders" but not actu-



Form 24. — Reverse.

ally issued, becomes less than quantity "Minimum Stock" a new requisition must be made out. If stores or worked material are turned into storeroom from a job, slips, Form 26 or 27, are sent to balance of stores clerk, who credits under column "Received."

The balance of stores sheet, Form 21*a*, p. 330, under discussion reads minimum stock allowed 3000 8/7/11 — 5000 ordered on purchase order No. 84732. Same received 8/7/11. 9/18/11 — 7500 ordered on "Y" order # 3246, not yet received — 8/21/11 — 50 turned in on credit slip. 8/17/11 — 3 issued to regular order 67592 and 8/19/11 — 200 to engineering order # 3094. Balance on hand 8/21/11, 4847. Quantity applied on orders


WORKED MATERIALS RECEIVED IN STORES

WORKED MATERIALS TAG NO.

		UNIT	TOTAL VALUE
PIECES LOST			
PIECES SCRAPPED		THE STOREKEEPER WILL NOT ENTER ANY VALUES ON WORKED MATERIAL TAGS IN STORES NOR ON THIS SHEET.	
PIECES DAMAGED			
PIECES O. K.			
TOTAL GOOD PIECES ACCEPTED IN STORES W. M.		TOTAL WEIGHT LBS.	MONTH / DAY / YEAR 191

I HAVE RECEIVED THE ABOVE WORKED MATERIALS IN W. M. STORES AND HAVE TIED WORKED MATERIALS TAG ON THEM AND ENTERED THE QUANTITY RECEIVED ON THAT TAG

REMARKS

TAGS | BALANCE SHEET | SIGNATURE OF STOREKEEPER OR HIS REPRESENTATIVE | SIGNATURE OF INSPECTOR WHO DELIVERS GOODS TO STORES

Form 25

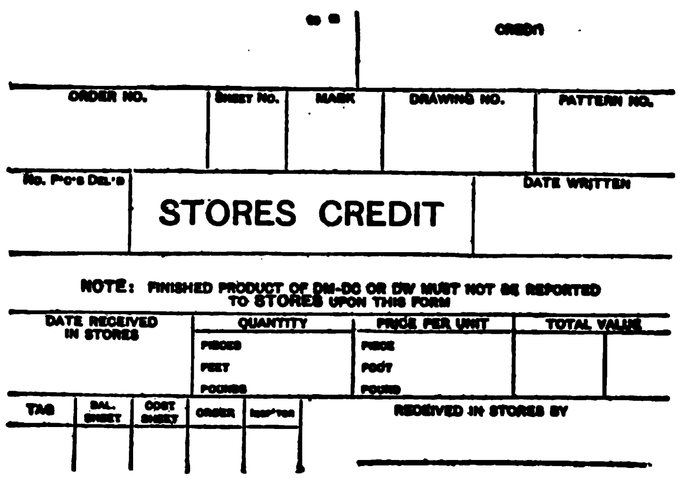
FORM 25. — Storekeeper's Receipt.

in hand in shops 3700. Quantity available for issue 1147. A new requisition must be made at once, as this quantity is less than minimum. Obviously the 3700 that are reserved for jobs under way in the shops cannot be available for future orders. When performing functions pertaining to stores the balance of stores clerk is technically in the cost department.

Receiving and Storeroom

Receiving. — Stores may be issued from three sources: (1) Purchased, (2) Worked material made in plant, (3) Foundry, which is a form of purchase.

In case (1) the storekeeper is furnished a copy of the purchase order. Upon receipt of stores he checks up this order and notifies balance of stores clerk of receipt of stores by form and enters quantity on receiving bin tag, Form 24, if stores go into bin, or attaches a bin tag and another tag, Form 28, if the stores are


ORDER NO. | SHEET NO. | MARK | DRAWING NO. | PATTERN NO.

NO. PC'S DEL'D | STORES CREDIT | DATE WRITTEN

NOTE: FINISHED PRODUCT OF DM-DO OR DW MUST NOT BE REPORTED TO STORES UPON THIS FORM

DATE RECEIVED IN STORES | QUANTITY (PIECES, FEET, POUNDS) | PRICE PER UNIT (PIECE, FOOT, POUND) | TOTAL VALUE

TAG | BAL. SHEET | COST SHEET | ORDER | INSP'TOR | RECEIVED IN STORES BY

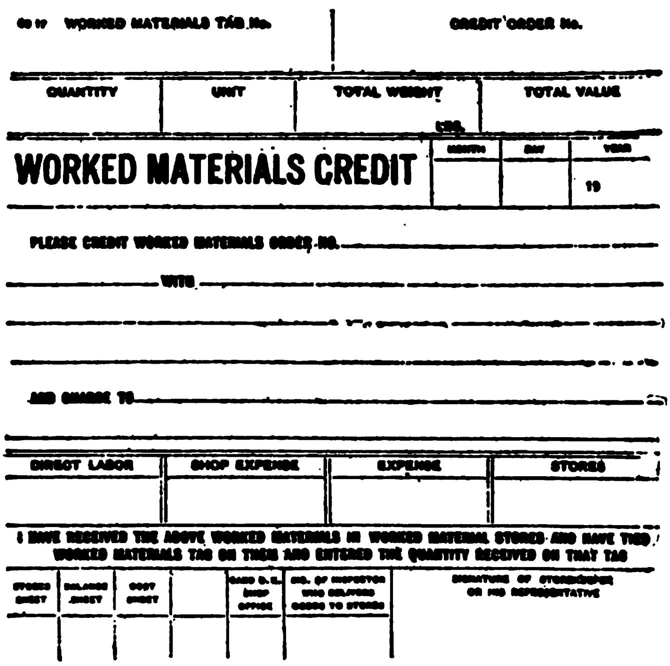
Form 26. — Stores Credit Slip.

destined for a particular job. In the latter case the route tag, when received by the storekeeper, is substituted for the bin tag which is destroyed, and both tags now on the item remain with it to completion in the shops.

In case (2) worked material made in plant, the material is turned into the bin and entered on the bin tag, notification being sent as stated under "Balance of Stores Clerk," on Form 25.

In case (3) the procedure follows the second variation of case 1. A bin tag and foundry tag, Form 29, are put on the castings. As in the former case the route tag when received is substituted for the bin tag. Notification of receipts of castings is made to the balance of stores clerk, etc., on Form 30, and to the order of work clerk for his route sheet file on Form 31.

Stores drawn for a job order may be returned to the store, in which case the storekeeper sends slip, Form 26 or Form 27, to



FORM 27. — Worked Materials Credit Slip.

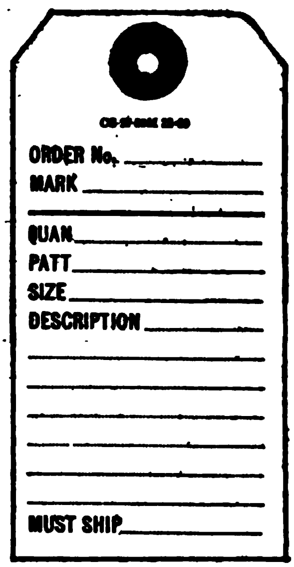
the balance of stores clerk for his stores sheet, and this also serves as a notification to the cost department to credit the job order with stores not used.

ISSUING

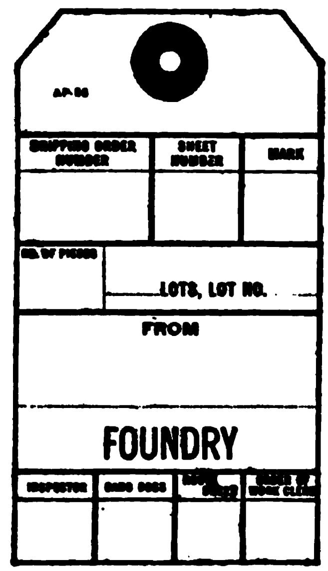
When Form 12 or 17 is presented to the storekeeper, stores are issued, the forms being retained. Tags on issuing bins are debited with stores issued. The forms are sent to the balance of stores clerk for his records and then go to the cost department for debit on the job order to which they are applied.

Storekeeping

Articles which are carried in quantity are stored in bins. Each item has two bins, a receiving and issuing bin, with a bin tag on each. All receipts go to one bin and all issues come from the other. In this way a check is obtained on the item account.



Form 28. — Job Order Tag.



Form 29. — Foundry Tag.

When the issuing bin is empty, if the tag does not read o the account can be readjusted, the balance of stores clerk being notified. When the issuing bin is emptied it becomes the new receiving bin and the old receiving bin becomes the new issuing bin, until it in turn is emptied.

Articles too bulky for storage in bins are stored with a single bin tag, and the only check possible with this class of stores is an inventory.

Receiving Floor

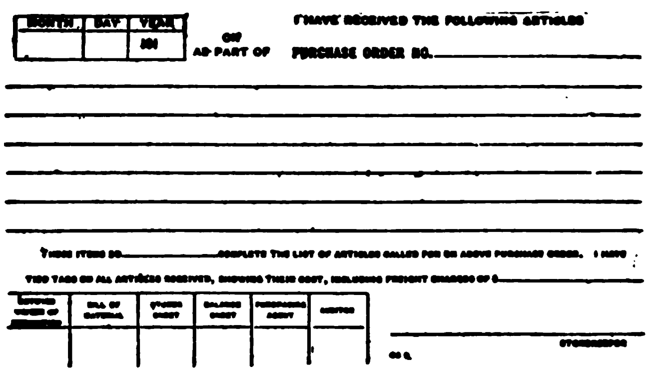
All stores are received on the receiving floor. They are tagged immediately upon receipt. The following form is used for convenience in checking in stores:

Memo. of	Order No.	Sheet and Mach.	Quantity and Description	Bin No. or Floor

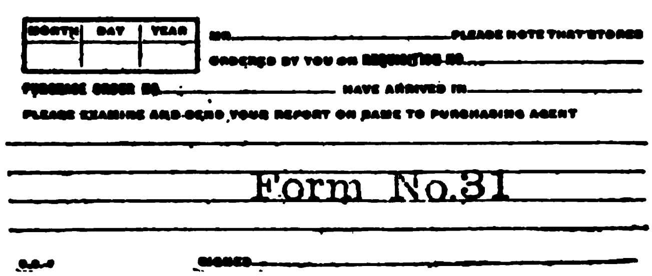
They are then treated as described under receiving. Freight receipts are reported on Form 32 (see page 340).

INVENTORY

An inventory is taken annually, but all items are not inventoried simultaneously. An inventory is taken of several classes


MONTH DAY YEAR
191
ON
AS PART OF
I HAVE RECEIVED THE FOLLOWING ARTICLES
PURCHASE ORDER NO.
STOREKEEPER

FORM 30. — Notification of Stores Receipt.


MONTH DAY YEAR
NO. PLEASE NOTE THAT STORES
ORDERED BY YOU ON REQUISITION NO.
PURCHASE ORDER NO. HAVE ARRIVED IN
PLEASE EXAMINE AND SEND YOUR REPORT ON SAME TO PURCHASING AGENT
Form No.31
SIGNED

FORM 31. — Notification of Stores Receipt.

each month so that at the year's end the storeroom has been entirely covered. This prevents business interruption for this purpose.

FORM 35

Production Clerk and Shipping

The production clerk's function is briefly to get the work out of the shop, coöperating with and notifying the planning room foreman if there is any probability of delay in shipment.

He is the head of the shipping department and keeps the tickler.

He is informed of the progress of an order at all stages and keeps a record of such progress on Form No. 33 (AP35). He is informed of the receipt of material in the shop by

1. Manifest in the case of castings.

2. Copy of Form 7 in the case of purchased material.

He keeps a foundry board on which is recorded the dates castings are due, and keeps a record of their receipt on this according to the three color scheme explained later in the case of D. M. and D. W. shipping boards.

Silent and regular orders come from the contract department to the production clerk to be checked for rush orders so that the material for these jobs can be started before the order is written. In this connection the production clerk notes the date of shipment and enters it on the D. M. and D. W. shipping boards for the planning department foreman's information. In case of doubt the latter are consulted in fixing this date.

Engineering order shipping dates are not entered on the shop shipping boards. Instead, each department, etc., concerned has a list of same, called a "Bill of Material Shipping List." This list shows: Firm, order No., date of shipment, preferred and penalty orders, etc. Daily at 9 A. M. the production clerk, planning room foremen and shop foremen meet in the superintendent's office and discuss the progress of this list.

The original and a copy of each order is sent to the shipping department; the copy goes to the packing room. Goods are packed and shipped as per route previously designated on the order by the production clerk.

When the goods are all checked and packed the copy is returned to the shipping department and the original is sent to the billing department. The copy is left on file for a couple of months and then destroyed.

SHIPPING LIST

Silent Chain Orders

C.	19393 P. R. R. Direct 9–8.	R	67439	Wagon.
	19403 Direct 9–7.		67493	P. & R.
	19408 Cancelled.		67560	"
	19412 Ad. Ex.		67592	"
	19475 Direct 9–7.		67593	Ad. Ex.
	19658 P. & R.		67610	"
	19696 P. & R.		67567	Direct 9–8.
	19727 Direct 8–31.		67704	Boat.
	19780 Mail Direct 9–6.		67861	P. R. R.
	19781 U. S. Ex. Direct 9–8.		67970	Boat.
	19787 Cancelled.		67984	U. S. Ex.
	19854 Ad. Ex.		67990	Wagon.

Bill of Material Orders

W	2042 X7.	68030	Boat.
	2232 X2 Ad. Ex.	68031	P. & R.
	3024 X7.	68034	U. S. Ex.
	3007 X2 U. S. Ex.	68044	Cancelled.
	3046 X3.	68045	Ad. Ex.
A/O.	3225 Wagon 3 and 7.	68073	Bearer.
A/O.	3235 Wagon.	68074	Mail.
	68009 Wagon.		

Regular Orders

R	66227 P. R. R.	68076	U. S. Ex.
	66960 P. R. R.	68077	U. S. Ex.
	68075 P. R. R.		

Form No. 34. — Copy of Hectograph List Sent Out Daily.

Daily a list, Form 34, is made out of all orders shipped and twelve copies are distributed as follows:

Production clerk	2
Route sheet file	1
D. W.	2
D. M.	2
Cost department	1
Purchase department	1
Order department	1
Chief draftsman	1

The shop shipping boards are checked by the three color system.

Copies of B. M., Form 8, are destroyed in all departments on receipt of shipping lists. Form 33 (AP35) is destroyed by the production clerk. Goods are shipped on a shipping manifest, Form 35, the original of which is sent with the bill of lading, duplicate filed in the shipping room, and triplicate goes to the cost department. A memorandum is kept in a blank book of job, route, date, etc.

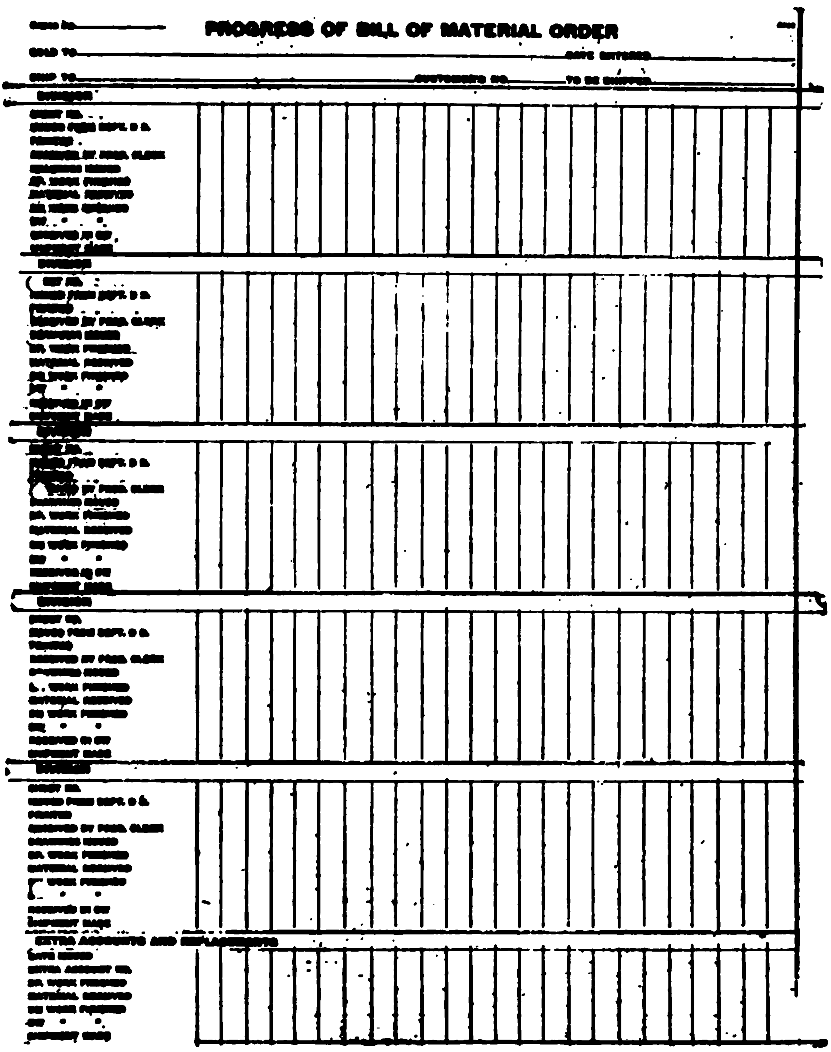
Correspondence *re* jobs late in shipment is sent to the production clerk for comment.

Tickler. — The tickler, which is now a part of any well regulated shop or office, takes the following form here:

A cabinet with a drawer for each month; in each drawer a large letter file with space for each day of the month. All tickler forms (Form 36) of the superintendent, planning department and shops are sent here for file by dates, and it is the production clerk's duty to daily distribute such ticklers of the day as are on file.

Shipping Boards in Planning Department. — These boards consist of heavy japanned sheet tins on which are pasted forms having a column for each day of the month. There is one board for each class of order, "R" and "C." The order numbers are entered in the column under date shipment is promised or desired. When order is shipped a colored mark is made at the order number as follows:

If shipped ahead of time, a purple star.
If shipped on time, a blue mark.
If shipped one day late, a red mark.
If shipped two days or more late, a yellow mark.



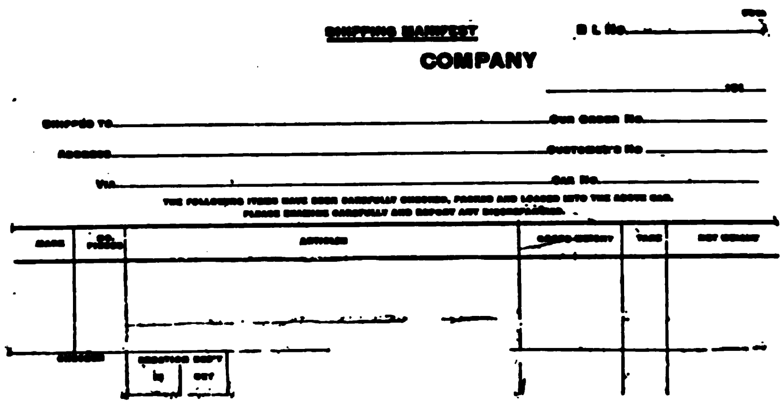
FORM 33. — Progress of Work kept by Production Clerk.

Cost Keeping Department

Analysis of a job order cost

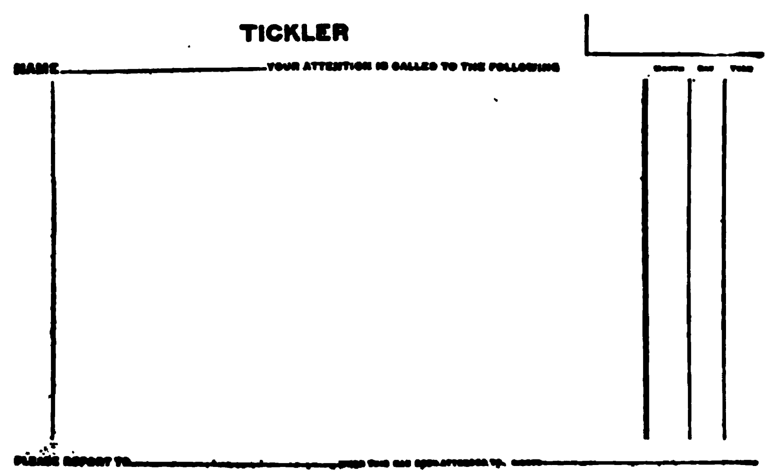
(Chart III to be read concurrently.)

The grand total selling cost of a job order is made up of (*a*) total selling cost for this plant and (*b*) total for other plants.



COMPANY

Form 35. — In Triplicate; Original, Duplicate and Triplicate so Marked.



TICKLER

Form 36. — Tickler.

This second item (*b*) consists of parts or articles manufactured for the job or bought but shipped from other plant direct and not handled at this plant.

(*a*) Total selling cost (of this plant) consists of (a1) total selling cost of worked materials by divisions. (NOTE: If the job is large, such as a coal-handling device, it is separated into divisions such as Hoppers, Springs, Chutes, etc., for convenience of planning, manufacture, etc., and each division is given a letter. If, for instance, the job order were 2035 the divisions would be known as 2035A, 2035B, etc. The accounts of the several divisions are

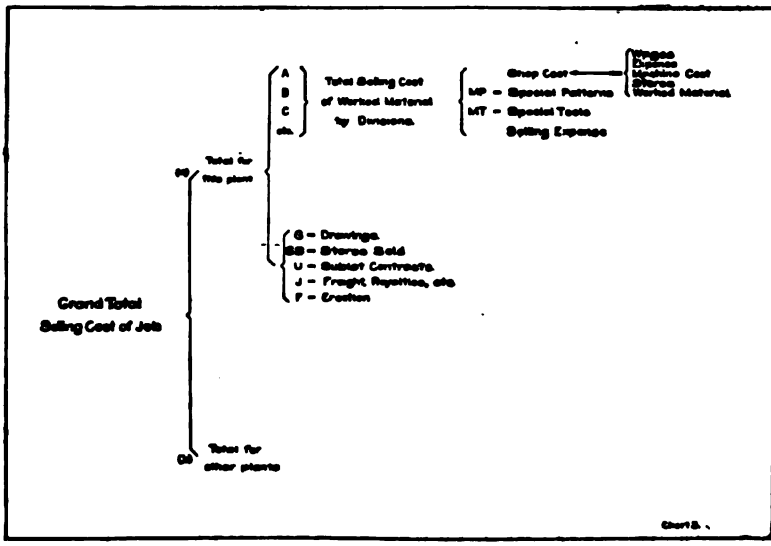


CHART III.

kept separately on all forms until the final cost summary is reached. This is not only a convenience in cost keeping but is essential to estimating and replacing; (a2) Drawings, G; (a3) Stores sold, SS; (a4) Sublet contracts, U; (a5) Freight, royalties, etc., J; and (a6) Erection, F.

(a1) *Total Selling Cost of Worked Materials by Divisions.* — Each division is made up of (a1a) shop cost of worked material; (a1b) special tools; (a1c) special patterns; and (a1d) general expense.

(a2) *Drawings, G.* — The cost of drawings is made up of (a2a) wages; (a2b) drawing expense; (a2c) general expense.

Chart 4.

SHOP NO.	Inv. No.	KIND OF MACHINE	SIZE	MAKER	COST PER HOUR	DEPRECIATION	MAINTENANCE	SMALL TOOLS	POWER	REMARKS	MOTOR H.P.	[illegible]	POWER HOUR
1B	83	Ver. Boring Mill	120"	Pond Machine Co.	52.3	482.20	381.00	164.44	501.30		43	25	3.6
2B	84	" " "	84"	" "		457.10	230.00	164.44	417.76		42	25	3.0
3B	89	" " "	64"	Gisholt Machine Co.		464.34	214.00	164.44	278.50		148	12	2.0
4B	87	Vert. Boring Mill	37"	Bullard Machine Tool Co.	25.3	202.00	142.00	98.66	208.80		76	9	1.5
5B	86	" " "	30"	Warner & Swasey		139.40	142.00	98.66	208.80		99	9	1.6
6B	85	Horiz. " "	8'x8'x56"	Newton Machine Co.		500.10	154.00	98.66	139.25		45	7.5	1.0
7B	88	" "	10'x10'x30"	Binsse Machine Tool Co.		135.00	89.00	98.66	97.48		65	9	.7
8B	81			M.M.&M.		93.00	226.00	98.60	196.95		100	9	1.6
1C	102	Gear Cutter	84"	Gould & Eberhardt	24.5	368.41	170.00	179.39	278.50		143	10	2.0
2C	114	" "	72"x6	Brown & Sharpe		244.30	120.00	179.39	181.08		37	18	1.3
3C	113	" "	60"x3	" "		173.88	120.00	179.39	153.17		"	"	1.1
4C	111	"	48"x8	" "		178.64	100.00	179.39	183.17		"	"	1.1
5C	117	" "	36"x4	" "		121.[illegible]	142.00	179.39	183.30		"	"	.9
6C	118	"	36"x3	" "		83.16	100.00	179.39	111.40		"	"	.8
7C	115	" "	36"x3	" "		84.08	100.00	179.39	111.40		"	"	.8
8C	119	"	48"x6	" "		214.84	100.00	179.39	183.10		69	6	1.1
9C	120	"	48"x5	" "		210.78	100.00	179.39	183.10		"	"	1.1
10C	121	"	36"x3	" "		73.46	100.00	179.39	111.40		37	18	.8
11C	122	" "	48"x6	" "		99.84	100.00	179.39	155.50		"	"	.9

Chart IV.

(a3) *Stores Sold* consist of stores delivered with an order as part of the order but direct from the storeroom and not made up as part of any of the worked material divisions. This cost consists of (a3a) invoice price of stores and (a3b) general expense.

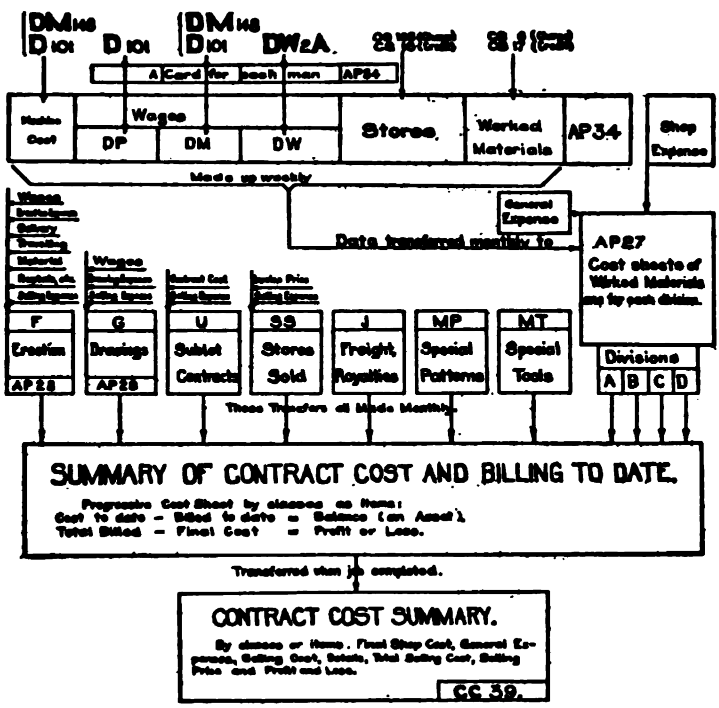


CHART V.

(a4) *Sublet Contracts* are parts of jobs let out and consist of (a4a) contract price and (a4b) general expense.

(a5) *Freight, Royalties, etc.*, are charged directly against the order without any change or additions to it for overhead expense.

(a6) *Erection* selling cost consists of (a6a) wages; (a6b) erection expense; (a6c) delivery; (a6d) travel; (a6e) materials; (a6f) rentals; and (a6g) general expense.

a1a. *Shop Cost of Worked Materials* is made up of (a1a1) wages; (a1a2) shop expense; (a1a3) machine cost; (a1a4) store; (a1a5) worked material stores.

a1b. *Special Tools.* — Tools made for a special job. The selling cost of these tools is charged to the order. This includes wages, shop expense, material (stores), and general expense.

WORKMAN'S NAME .... WORKMAN'S NO. D ....

YOUR TIME AND EARNINGS WERE AS FOLLOWS ON — DAY OF WEEK — DATE

TIME IN TENTHS OF AN HOUR	TIME ACTUALLY WORKED	ADDITIONAL TIME EARNED	TOTAL EARNINGS
ON STRAIGHT DAY WORK			
ON PREMIUM WORK			
ON PIECE WORK HIGH RATE			
ON PIECE WORK LOW RATE			
ON TIME WORKED ON CONTRACTS AND NOW ADVANCED ON SAME			
PIECE WORK RETAINERS			
OVER-TIME RETAINERS			
BALANCE DUE ON COMPLETED CONTRACTS, ETC., ON WHICH TIME AND MONEY HAVE BEEN ADVANCED			
TOTALS			

NOTE REPORT PROMPTLY IF THIS STATEMENT DOES NOT AGREE WITH YOUR OWN ACCOUNT.

SIGNED........................

FORM 37. — Pay Card, in Duplicate; Original White, Duplicate Manila. — Note Label.

RETURNED / ISSUED		CHARGE TO

ORDER NO.	SHEET NO.	MARK	DRAWING NO.	PATTERN NO.

No. Pcs. Ordered				IF NOT FINISHED SCRATCH OUT THIS ☞	F
				IF FINISHED SCRATCH OUT THIS ☞	NF

WORK TO BE PERFORMED

FORM 38. — Old D. M. Time Card.

a1c. *Special Patterns.* — Patterns made for a special job. The selling cost of these is charged to the order. This includes wages, shop expense, material (stores), and general expense.

IN / OUT		CHARGE SYMBOL

SHIPPING ORDER NUMBER	SHEET NUMBER	MARK	OPERATION NUMBER

DEPARTMENT DW DAY RATE	TOTAL TIME FOR HIGH PRICE	IF JOB IS NOT FINISHED SCRATCH OUT THIS	F
		IF JOB IS FINISHED SCRATCH OUT THIS	N F.

No. of Pieces Ordered	Total Price High	Total Price Low	No. of Pieces Finished	Amount Earned	Man's Time	Machine Time	Machine No.

Drawing No.	Pattern No.	Instruction Card	

Workman's Name — Workman's Number DW

Route Sheet		Pay Sheet	Cost Sheet Man's	Cost Sheet Machine's

GANG BOSS ....

DW 12A

TIME CARD

FORM 39. — D. W. Time Card for Bonus Work.

BONUS ON PREPARATION	TOTAL BONUS BASE RATE			BONUS PER PIECE	
Time for Preparation	High Rate	Low Rate	Time per Piece	High Rate	Low Rate

REMARKS

GANG BOSS

INSTRUCTIONS	Shape of Tool	Cut	Feed	Speed	Time

SIGNED ....

FORM 39. — Reverse.

a1d. ***General Expense.*** — **This is an amount to cover part of the administrative and selling expenses fixed as explained later under General Expense.**

a2. Drawings, G.

a2a. Wages. Pay actually given to the draftsmen employed on the drawings of the job.

a2b. Drawing Expense. Part of the overhead charges as explained under *Shop Expense.*

MONTH	WEEK	WAGES DC	WAGES DP	WAGES DM	WAGES DW	STORES	WORKED MATERIALS	
	1							
	2							
	3							
	4							
	5							
TOTALS								
	1							
	2							
	3							
	4							
	5							
TOTALS								
	1							
	2							
	3							
	4							
	5							
TOTALS								

Form 40. — Weekly Summary of Shop Cost.

a2c. General Expense. Same remarks as (a1d).

a3. Stores Sold.

a3a. Invoice Price of Stores, actual buying cost of material to be sold, no shop work to be done on them.

a3b. General Expense. Same remarks as (a1d).

a4. Sublet Contracts.

a4a. Selling Cost of Contract is price at which contract is let.

a4b. General Expense.

a6. Erection.

a6a. Wages. Pay to workmen actually in the field.

a6b. Erection Expense. Part of overhead charges, such as superintendent erection department and necessary men retained at all times when not chargeable to any particular order. Repairs to equipment of departments, etc.

a6c. Delivery. Cost of delivery of material from shop to the field.

a6d. Travel. Actual traveling expenses of party in the field.

DETAIL COST SHEET OF WORKED MATERIALS ON CONTRACT / WKD. MTL. LOT No.______

DESCRIPTION: ______

EXPENSE FACTORS USED: DC	DP	DM	DW		DATE STARTED	DATE FINISHED	CHARGE TO

MONTH										TOTAL
DC	WAGES									
	SHOP EXPENSE									
DP	WAGES									
	EXPENSE									
DM	WAGES									
	EXPENSE									
DW	WAGES									
	EXPENSE									
	WAGES									
	EXPENSE									
STORES										
[illegible]										
SHOP COST [illegible]										
SHOP COST TO DATE										
							GENERAL EXPENSE			
							TOTAL SELLING COST			
							ESTIMATED SHOP COST			

TOTAL QUANTITY PRODUCED	PIECES / FEET / POUNDS	SHOP COST PER UNIT	PIECE / FOOT / POUND	

SUMMARY OF MATERIALS USED	IRON CASTINGS						STEEL SHAPES		STEEL PLATES		MISCEL. STORES
	WEIGHT	[illegible]	WEIGHT	[illegible]	WEIGHT	[illegible]	WEIGHT	[illegible]	WEIGHT	[illegible]	AMOUNT

REMARKS: ______

FORM 41. — Monthly Cost Sheet of Worked Materials, Accounts of Contract.

a6e. Materials. Anything purchased in the field necessary for erection, example: bolts.

a6f. Rentals. Rent paid for shacks, derricks, boats, booms, etc.

a6g. General Expense.

a1a. Shop Cost of Worked Materials.

(a1a1) Wages. Money actually paid for labor.

(a1a2) Shop Expense. Overhead charges for shop. See Appendix I.

(a1a3). Machine Cost. Every machine is intended to earn at a certain rate. This actually writes off part of the overhead

DETAIL COST SHEET OF DRAWINGS, AND DELIVERY AND ERECTION ON CONTRACT No. ________

DESCRIPTION: ________

DRAWINGS									DATE STARTED	DATE FINISHED	CHARGE TO
MONTH										TOTAL	
WAGES											
DRAW. EXPENSE											
MISCELLANEOUS											
DRAW. ROOM COST FOR MONTH											
DRAW. ROOM COST TO DATE											
EXPENSE FACTORS USED: DRAWING / ERECTION / SELLING									GENERAL EXPENSE		
									TOTAL SELLING COST		
									ESTIMATED DRAW. ROOM COST		

DELIVERY AND ERECTION									DATE STARTED	DATE FINISHED	CHARGE TO
MONTH										TOTAL	
WAGES-FA											
ERECTION EXPENSE											
DELIVERY-FF											
TRAVELLING-FH											
MATERIAL-FH											
RENTALS, ETC.-FS											
COST FOR MONTH WITHOUT SELL. EXP.											
COST TO DATE WITHOUT SELLING EXPENSE											
REMARKS:									GENERAL EXPENSE		
									TOTAL SELLING COST		
									ESTIMATED COST WITHOUT SELLING EXPENSE		

FORM 42. — Monthly Cost Sheet for Drawing and Erection Accounts of Contract.

expenses of the shops but is carried as a separate account. The machines are numbered and a machine hour rate was originally determined as follows:

[Depreciation (7% annually) + maintenance (supplies and repairs) + small tools + power] ÷ 2500 = Machine hour cost.

Power is the annual cost of the power actually absorbed by the machine.

Small tools. Was estimated.

The figures in the numerator are for a year. This sum is divided by 2500 on the estimate of 2500 machine hours per year.

The machines are divided into groups, each group containing machines of approximate similarity and power. The average of the rates for any group is taken for the rates of all machines in the group. (Chart IV.)

Obviously for any piece of work machine cost = machine hours × machine hour cost, machine hours being the actual running time of the machine on the work in question.

(a1a4) Stores. Invoice price of stores drawn from the storeroom and used on an order.

(a1a5) Worked material. A certain class of stores are made in the shop and a stock kept in the storeroom. This item (a1a5) is the shop cost of this class of stores when drawn for use on an order.

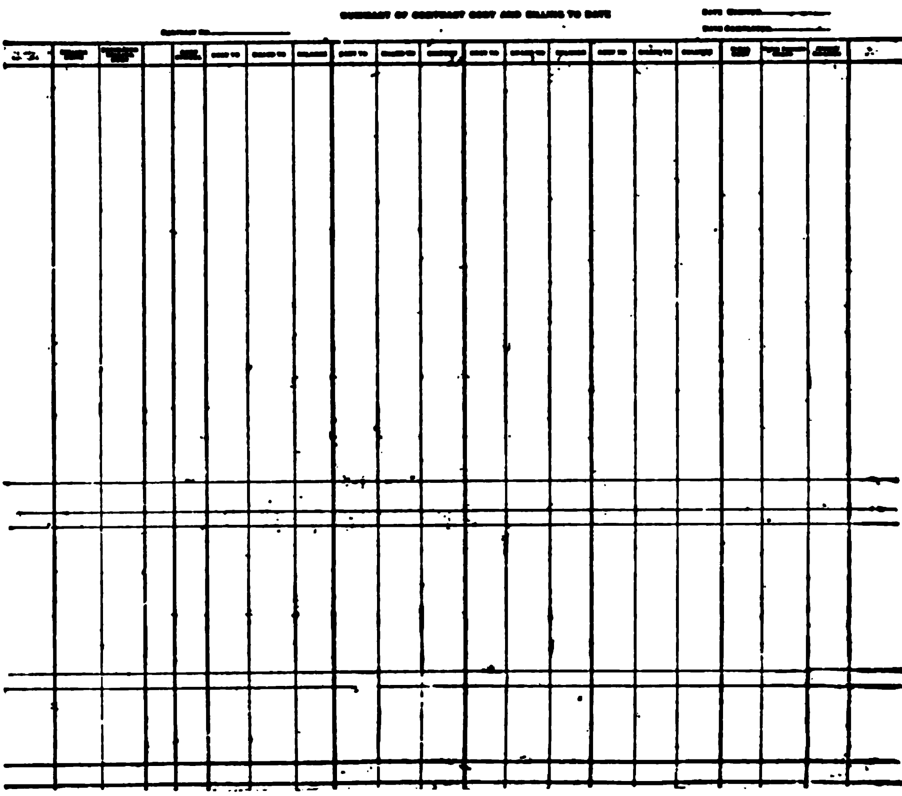
Method of Cost Keeping for a Job Order

(Chart V to be read concurrently.)

Time cards of work done are turned in to the cost department from the bulletin board daily. Times of starting and finishing the work are stamped on the cards, and the rate of pay appears on the cards. Two boys compute and enter on the card this elapsed time and the wages due the man. The cards are then sorted by men's numbers. Daily the pay for each man is computed and entered on Form 37 (AP54) in duplicate. The man receives the white copy daily through the time box, showing his earnings for the previous day, the yellow copy being filed for computing the weekly wages due the man.

Form 37. — Used to summarize the daily earnings of the workman. The white copy is placed in the time box daily showing the man's earnings for the previous day. The time box referred to is a locked box having a compartment for each man. This box is opened fifteen minutes before starting time in the morning, and a boy is stationed at the box while open. It is closed at starting time. This box is employed in lieu of a time clock, any men coming after the box is locked have their time stamped at the Order of Work Clerk's desk. Only the office use a time clock for arrival and departure. It is worth noting that everybody from the president of the company down stamps the office clock, and the moral effect of this is keenly felt.

Time cards, Forms 13, 38 or 39 (DM148, D101, or DW2A), are again assorted by divisions of worked material job numbers



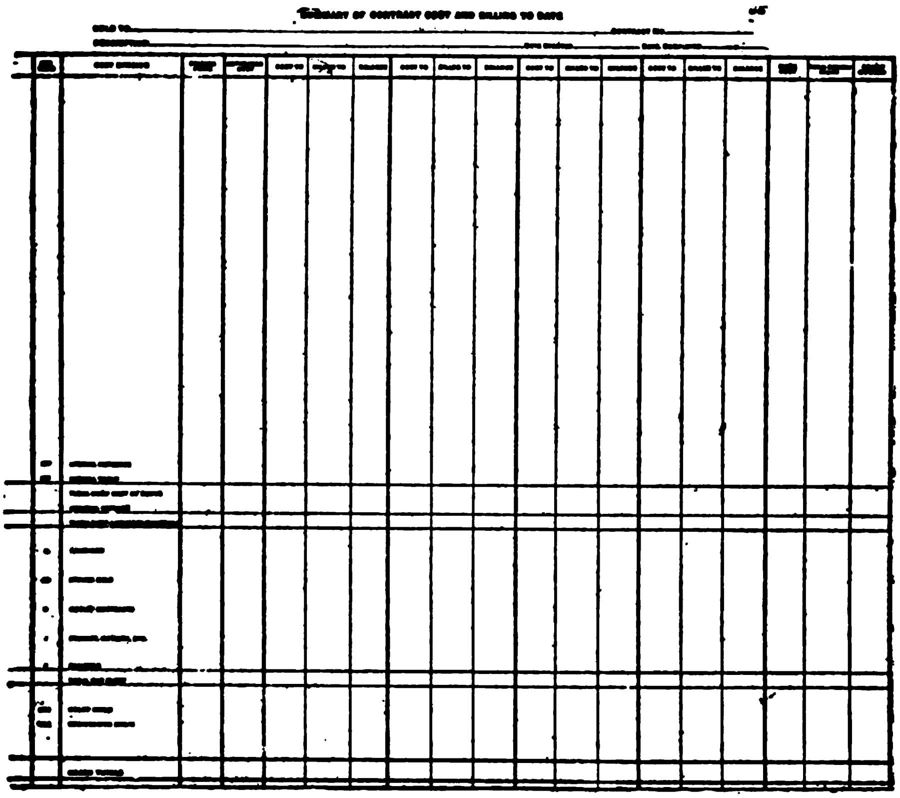
FORM 43. — New Form.

(charge number) and entered weekly by labor divisions on Form 40 (AP34). Thus the wages entry is charged against each division of the job.

Time cards of the machine shop, DM, Forms 13 or 38, are again sorted and the machine cost is entered on each card in red ink, computed as follows: The number of the machine appears on the card and reference to a table gives the machine hour cost. The machine hours are the same as the man's time on the card.

Obviously the machine cost equals the machine hours multiplied by the machine hour cost.

Machine Hour Cost. — This is computed from Chart number IV, as follows: (Depreciation + Maintenance + Small tools +



FORM 43. — Old Form.

Power) divided by 2500 equals the machine hour cost, as previously explained.

After the machine cost is entered on the cards they are again assorted by job divisions and the machine cost is entered weekly on Form 40 (AP34), under column D. C.

The value of stores drawn from the storeroom and applied to the job is entered weekly on Form 40 from slips, Form 12 (CS103), and likewise the value of worked materials drawn from the store and applied to the job is entered on Form 40 from slips, Form 17 (CS6). Before entering values of stores drawn, any credits from Forms 26 (CS16) and 27 (CS8) are deducted.

Monthly the totals of wages, machine cost, stores and worked materials stores charged to each division are transferred from Form 40 to Form 41 (AP27) and checked. There is one copy of Forms 40 and 41 for each division of the order. These are specified as lot Nos., thus: W2035A, W2035B, etc.

Under each line of wages, Form 41, is a line marked expense. This is determined as follows: The shop expense factor for each department, shown at the top of the page (how found and functions shown later), is multiplied into the wages for the month in the corresponding department and this is entered as expense.

Example. — Wages DP \$.45. Factor DP .50.

Expense DP is \$.45 × .50 = \$.23.

This expense covers what is commonly called overhead or shop expense (exclusive of machine cost) as shown in accounts A and D, Appendix 1.

Average Shop Expense Factor. — The average shop expense factor is determined as follows: The total shop expense for a period of three years is apportioned to the several shops in proportion to the amount of this expense incurred by each. This expense in each shop is then divided by the total productive wages in the shop for the same period. In this way a different factor for each shop is obtained, for example:

DP	50%
DM	110%
DW	75%

(NOTE. — These, of course, are not the actual figures at this plant. These factors are applied as shown on Form AP27, and when applied in a normal year should cover all expense incurred under Accounts A and D. (See Appendix 1.) These expenses are such as experiments for the benefits of engineering and manufacturing, heat, light and power, planning connected with machines and materials, etc., and in the several departments DD drawing, DM machine shop, DP pattern shop, and DW wrought shop, such expenses as are connected with manufacturing that cannot be charged to any particular order. A study of this with table of accounts A and D should make the matter clear.)

The factor as found for the machine shop is not used as it now stands, but is again modified as follows: In a certain class of repeat work (gear cutting for silent gears) one man can run a number of machines. Now, since the factor is applied to wages and since in this special case the ratio of wages to output is greatly reduced, it becomes necessary to increase the factor applied to this special line and decrease that used for the remainder of the shop product in order that this line carry the proportion of shop expense warranted by the tools used, the floor space occupied, and all other considerations governing expense. Therefore the readjustment might be as follows:

DP 50%
DW...... 75%
DM......100%......Regular
DM......120%......Special

This is so adjusted that 50% wages DP + 75% wages DW + 100% wages DM (regular) + 120% wages DM (special) = total shop expense.

After all wages, expenses, machine cost stores and worked materials are entered in the monthly column of Form 41 (AP27), the total of column for the month obviously gives the shop cost for the month. Theoretically all money spent on the production, all expenses incidental to production, and the product's share of the shop expenses inherent to all shop output have been charged.

This sheet is progressive in that monthly costs are carried forward and totaled to date at the end of every month, resulting in shop cost to date.

After the total shop cost is arrived at, addition of the general expense gives the total selling cost. A general expense factor is used in a manner similar to the shop expense factor. It is determined as follows:

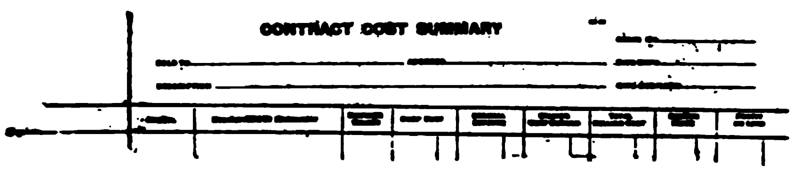
General Expense Factor. — This factor is used to cover what are known as administrative and selling expenses, Account C.

These include such items as office salaries, wages and watchmen; repairs and maintenance to all buildings other than shops; planning connected mainly with workmen; contract and sales department; branch officer; shipping room, etc. (See Account C, Appendix 1.)

General expense is distributed over the following items:

(1) Shop cost of worked materials; (2) Drawings; (3) Erection; (4) Stores sold; and (5) Sublet contracts.

A factor was first derived by dividing the average general expense for a number of years by the average of the total of the above five items for the same period. For demonstration let us use 30% as the derived factor. Obviously 30% is an excessive


CONTRACT COST SUMMARY

FORM 44.

amount to saddle on such accounts as erection, stores sold, and sublet contracts. In the case of erection a general expense factor was determined from items covered by Account E (Appendix 1). This account in a general way covers all expenses of erection gangs that cannot be charged to any particular order. This Account E for a number of successive years divided by the wages in erection department for the same period gives the erection expense factor.

In the case of stores and sublet contracts a factor was determined from good commercial practice. This is arbitrary and depends upon what the product will stand without killing orders.

Having reduced the factor over some of the items, it becomes necessary to increase the factors used in the case of drawings and shop cost of worked materials enough to equalize the total general expense of the plant when found by these different factors applied to the shop cost of the respective items, and the total general expense as found if the first derived factor were used throughout all the items.

The factor applied to worked materials is a little larger than that applied to drawings, for several reasons. Drawings are not affected by shipping or stores. Also if the machine hours fall below those used when computing the machine hour cost, the power that will be written off in machine cost is reduced and this margin is covered by this factor. Also if several machines are run by one man in the DM the total shop cost of the products at these machines is reduced. There is no parallel saving in the drawing department. The total shop cost being reduced it is necessary to increase the factor.

Whereas a factor of 30% was first derived, after all these adjustments the factors would look something like the following:

Worked materials................	32%
Drawings......................	28%
Erection.......................	20%
Stores sold.....................	15%
Sublet contracts.................	10%

(NOTE. — These are not in any proportion to the Company's figures.)

These factors are applied as follows:

1. Shop cost of worked materials × 1.32 = selling cost of worked materials, Form 41.

2. Shop cost of drawings × 1.28 = selling cost of drawings.

3. 1.20 wages + erection expense + deliveries + traveling + material bought in the field + rentals = selling cost of erection contract.

(NOTE. — Factor is applied to wages only. See Form 42 (AP28).

4. 1.15 invoice price of stores sold = selling cost of S. S., Form 43 (AP58).

5. 1.10 contract price of sublet contracts = selling cost of sublet contracts, Form 34 (AP58).

There is still another correction to be made in the case of this particular shop before the factors are settled. In the case of a special line of goods called Silent Orders (silent gears and chain) it is found that a far greater expense is incurred per dollar of order to get orders in this special line than is incurred getting the regular orders. So the factor on worked materials is again altered, and since the value of silent orders is but a small proportion of the whole shop output the factor on this line rises rapidly thus:

Original factor	32%
New factors:	
Regular DM	30%
Silents	45%

All factors, as stated above, were derived from the average of a number of years. They are seldom changed, and therefore the general expense for any given period, say one month, as computed by them will not exactly equal the actual selling expense for that period, although it is surprising how closely these two figures agree. The slight difference is taken care of by profit and loss adjustment.

Monthly all data is transferred from all Form 41 sheets of any job and from Form 42 onto Form 43 (AP58), and stores sold, sublet contracts, freight and erection are all entered on Form 43 (AP58). This sheet is a progressive monthly summary of details. All goods billed to customer during the progress of the work are charged off this sheet by the pound at a pound price, and the difference between the selling cost to date and the goods billed to date = balance, which is an asset.

When a job is completed. — All items are transferred from Form 43 to Form 44 (CC39), which is a final contract cost summary of the job by divisions, showing the profit or loss on same.

APPENDIX

Account A. — Auxiliary Departments

AE. — *Experiments for the Benefit of Engineering and Manufacturing.* — Includes all labor and material used in the making of experiments for the benefit of engineering and manufacture, and any other expenses connected therewith. Experiments for the benefit of sales department, Account C.

AH. — *Heat, Light and Power.* — Includes the labor and materials used in making steam, transmitting power, heating, electric and other light, water, etc., and also all labor and material used in repairing and maintaining the apparatus, machines, buildings, etc., in this department.

AP. — *Planning Connected Mainly with Machines and Materials.* — Includes all labor and materials used in the planning work connected mainly with machines and materials, when the same cannot be charged directly to a particular department. Also the *Maintenance of the Planning Room.*

(See detailed subheads AH and AP.)

HEAT, LIGHT AND POWER DEPARTMENT. — AH

AHA. — *Engineer, Assistant, Firemen and all Miscellaneous Labor.* — Such as for cleaning, unloading coal, loading ashes, etc., which cannot be charged to some other expense symbol of this department.

AHB. — *Fixture and Furniture.* — Includes such items as benches, cupboards, shelving, partitions, desks, clocks, etc., repairs and maintenance but not new. Charges against new or improvements charged against Account X.

Stores and supplies, including stationery, which cannot be charged to one of the other expense items of this department. Also all small tools used in this department that are not borrowed from the tool room. *Repairs, Maintenance and New.*

AHC. — *Boilers, Stacks, Flues, and Ashes Elevators.* — Includes all labor and material for overhauling, scaling, testing, etc., *repairs and maintenance but not new.* Charges for new and improvements to Account Y.

AHP. — *Power and Transmission of Power.* — Includes engines, generators, motors, compressors, pumps and piping to main distribution valve, and all wiring to main distributing switch, *repairs and maintenance but not new.* New and improvements charged to Account Y.

AHZ. — *Buildings, Repairs of.* — Includes *repairs and maintenance of* buildings, floors, steam heat and water-supply system from main valves, including all alterations and repairs to patterns and drawings required by this work. Charged for new and improvements charged to Account Z.

PLANNING FOR MACHINES AND MATERIAL. — AP

APA. — *Shop Engineer, Production Clerk,* and also all clerks, messengers, etc., whose work is mainly connected with *planning for machines and materials,* and which is not chargeable to any other department order.

APB. — *Fixtures, Furniture and Apparatus,* includes such items as benches, shelving, partitions, desks, tables, stools, chairs, clocks, electric fans and other electrical apparatus, wiring, etc. *Repairs and maintenance but not new.* New and improvement charged to Account X.

Stores and supplies, including stationery, used in the planning room and which cannot be charged to a particular manufacturing, equipment, construction or other department order.

APR. — *Reclamation for Errors* made in planning for machines and materials.

Synopsis of General Expense. — Account C

CA. — Accounting department.
CB. — Purchasing department.
CC. — Sales department.
CD. — Estimating department.
CE. — Stenographic department.
CF. — Photographic department.
CG. — Order department.
CH. — Entertainment department.
CJ. — Replacements and diplomatic extra work.
CK. — Exchange and collection expense.
CL. — St. Louis office.
CM. — Seattle office.
CN. — New York office.
CO. — Silent chain sales department.
CP. — Pittsburgh office.
CR. — Lunch room.
CS. — Stores department.
CU. — Boston office.
CV. — Buffalo office.
CW. — Shipping room.
CX. — Charities and contributions.
CY. — Telephones and telegraphs.
CZ. — Repairs to office building.

Manufacturing Department. — Account D

DD. — Drawing room.
DM. — Machine shop.
DP. — Pattern shop.
DW. — Wrought shop.

Machine Shop Department. — DM

Note. — All other shop departments are made up of similar subdivisions, so only the machine shop is exhibited.

DMA. — *All Functional Foremen, their Assistants* and all labor that cannot be charged to a particular manufacturing, construction, equipment, or other department order, or to one of the other expense items of this department, including machine shop tool room. Also the rate setters and route clerks in the planning department that work only for the benefit of the machine shop.

DMB. — *Fixtures and Furniture, Including Tool Room.* — Includes such items as benches, cupboards, shelving, racks, partitions, shop lockers, desks, tables, stools, clocks, tote-boxes, trucks, scales, bulletin boards, etc. *Repairs and maintenance but not new.* Charge for new to Account X.

Stores and Supplies, including stationery; such as waste, oil, etc., which cannot be charged to a particular manufacturing, equipment, construction or other department order; or to some one of the particular expense items of this department.

DME. — *Small Tools.* — Includes the repairing and maintaining of small tools such as drills, chisels, planer and lathe tools, dies, milling cutters, etc. Also the making of these tools, including the tool steel used therein, machining and dressing, and all tools of this kind that are drawn from stores for the purpose of only maintaining the tool room stock and not with a view of increasing same. Charges for new tools *increasing the tool room stock* charged to Account X.

Large Hand Tools. — Includes those tools which do not depreciate rapidly by use, and which add to the permanent value of the shop equipment, such as vises, anvils, pulleys, blocks, jacks, etc. *Repairs and maintenance* but not new. New and improvements charged to Account X.

Grinding and Dressing of Tools. — Includes the grinding and dressing of old tools, and the treatment of new and old tools. The dressing of new tools is not included in this item, the work being charged to the order for the manufacture of tools.

DMH. — *Special Tools.* — Includes such tools as jigs, gages and templates which cannot be charged to a particular manufacturing, equipment, construction or other department order. *Repairs and maintenance and new.*

DMK. — *Work on Defective Material.* — *i. e.*, work done by the shops on material that has concealed defects, that is, such as disclose themselves only after some work has been done.

Note. — Work done on defective material, the defect in which could and should have been discovered before any work is done, is to be charged against CSR, it being due to an error on the part of the stores inspector.

DMM. — *Machines Operated by Hand or Power, Including Cranes.* — Includes all machines with their countershafts or motors and all cranes operated by hand or power. *Repairs and maintenance but not new*, including any alterations and repairs of patterns and drawings required by this work. *New* and improvements charged to Account Y. Also,

Power and Transmission of Power. — Includes all compressed air lines within the buildings (main), line shafting and their motors and all electrical fixtures and wiring for both power and light. *Repairs and maintenance but not new.* Charges for new and improvements except electrical fixtures and wiring charged to Y. Fixtures and wiring charged to Account X. Also,

Belting. — Includes labor and materials used for repairing and maintaining all belts in the machine shop. Also the cost of new belting replacing old, and all belt lacing, glue and small tools used by the belt fixer. *New* belts for new machines and for line shafting charged to different divisions of Account Y.

DMN. — *Retainers.* — Both for piece work (DMNP) and overtime (DMNT) connected with worked materials, and construction and part construction.

DMR. — *Reclamation for Errors* made by the machine shop or tool room.

DMV. — *Repairs to Patterns.* — Includes all labor and materials used in repairing patterns, and in handling and transporting patterns, including freight and expressage. Also *repairs and maintenance of pattern shed.* Charges for *new patterns* that cannot be made to a particular manufacturing, equipment, construction or other department order, are to be made to Account X.

DMW. — *Painting and Moving, and Other Miscellaneous Labor.* — Including all labor and material used in painting and oiling worked material produced in the machine shop, and also all labor used in moving materials in the machine shop. Also, oiling and cleaning of all line shafting and motors, machines when not in operation, shop floors, windows, etc.

DMZ. — *Buildings.* — Includes *repairs and maintenance* of buildings, washrooms, washroom fixtures, urinals, waterclosets and soil pipes, inside of machine building, exclusive of that part occupied by offices. Also, steam-heat and water-supply system from main valves, including any alterations or repairs to patterns and drawings required by this work. Charges for new and improvements are to be charged to Account Z.

ERECTING EXPENSE

Erection Department. — E

When any of the following symbols are used, they indicate that some one of the following kinds of expense has been incurred chargeable to the above department.

EA. — *Superintendent of Erection Department, Assistants, Foreman Gang Bosses, Clerks and Workmen* when their work cannot be charged to a particular *delivery* or *erection* order.

EB. — *Fixtures, Furniture, etc.* — Includes benches, cupboards, shelving, partitions, desk and office furniture, clocks, tool boxes, etc. *Repairs and maintenance but not new.* Charges for new or improvements are to be made on proper written authority to (XCB). Also,

Stores and Supplies, Including Stationery, which cannot be charged to a particular manufacturing, equipment, construction or other department order, or to one of the other expense items of this department.

EE. — *Small Tools.* — Includes all small tools purchased or manufactured, which are used by hand and must be replaced frequently on account of wear, and hence cannot be considered as adding to the permanent value of the equipment, such as hammers, wrenches, chisels, rope, bars, shovels, etc., including repairs and maintenance of same. Also,

Large Hand Tools and Machines. — Includes those tools which do not depreciate rapidly from use and wear, and which add to the permanent value of the equipment, such as hoisting engines, winches, etc. *Repairs and maintenance but not new.* Charges for new and improvements are to be made on proper written authority to (XEF).

EM. — *Miscellaneous.* — Includes all cost of living, traveling, and stores and supplies chargeable to this department and which cannot be charged to a particular *delivery* and *erection* order.

ER. — *Reclamation for Errors* made by this department.

EW. — *Starting up.* — Includes all extra expense incurred in starting up machinery, which cannot be charged to any particular *delivery* and *erection* order.

EU. — *Unloading and Loading.* — Includes that which cannot be charged to any particular *delivery* and *erection* order. This refers especially to handling of erection tools.

EZ. — *Buildings, Repairs of.* — Includes repairs and maintenance of any permanent building that might be built by this department. Charges against new or improvements are to be made on proper written authority to (ZE).

Account X referred to in the foregoing is part construction, and includes fixtures, apparatus, etc., part of the cost of which goes to construction and part to shop expense or general expense and which increases the permanent value of the plant.

Account Y is construction, and consists of machinery, tools and motive power that adds to the permanent value of the plant. Account Z is construction, and consists of real estate, buildings, etc.

THE PLANNING DEPARTMENT, ITS ORGANIZATION AND FUNCTION

By H. K. HATHAWAY

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It has not been such a long time since machinery was constructed without drawings except those of a most primitive and general sort; and details were almost entirely left to be worked out during the process of construction by the mechanic who did the work.

The passing of that type of mechanic who, as it once was expressed by an engineer of the old school, " was able to not only construct a fiddle but to play a tune on it as well," has been deplored by those who fail to see that the all round mechanic of yesterday is the engineer, the draftsman, the chemist, and the foreman of to-day; and it must be admitted that through the changes that have taken place, from both social and economic standpoints, the world has gained far more than it has lost.

The making of complete detail drawings in a drafting department, in place of leaving much, if not all of it, to be done in the shop by the workman, is nothing more or less than planning — planning what is to be constructed. No engineer or mechanic today objects to this; in fact, he objects if drawings are not sufficiently clear and complete to enable the prosecution of his work without hesitation or doubt.

Still, we frequently find the strange inconsistency of employers and managers of the old school, who regard a drafting room and complete detail drawings as essential to economic manufacture, as well as workmen who object to working without good drawings, opposing the carrying of the planning of work one step nearer to completion. The employer of the old school is prone to regard the planning department force as " non-producers "; and in his conception of good management, keeping down the so-called " non-productive " expense is an essential.

In a properly organized and properly run planning department there is no such thing as a " non-producer "; every person in the planning department is there to perform some specific function, which assists in making it possible for those in the shop to attain greater efficiency, and to secure the maximum efficiency of the equipment and plant as a whole.

The function of a designing or drafting department is planning what is to be done. The functions of a planning department are planning how it is to be done, and when it is to be done. Just as it is now unusual to find an engineering plant in which there is no drafting room, so in time will it be unusual to find a manufacturing plant of any sort without an efficiently organized planning department.

The sort of opposition referred to — usually met with in those who know little or nothing of Scientific Management, or who have a mistaken idea of it — is rapidly disappearing as the true doctrine of Scientific Management becomes better understood. Workmen have opposed Scientific Management as they opposed machinery, and in doing so commit just as grave an error, failing to see that it is another means to shorter hours of labor and to increased material returns. Mr. Taylor has repeatedly made the statement that the greatest fallacy existing in the minds of the workingmen of the world is that it is to their interest, in the long run, to restrict output. Restriction of output by manufacturers, or proprietors of the means of production, for the purpose of keeping up prices is equally vicious and short-sighted. We would most of us like to have better homes, more conveniences and comforts, and after their achievement more time to enjoy them; but how are we to have these things if we do not produce them ?

Parallel to the workmen's error — belief in curtailment of output — we find that in the past, very generally, and even now to a considerable extent, employers have believed it to their interest to pay the workman as little as possible; and to secure results through driving him without regard to his welfare, rather than through affording him such assistance as would enable him, without over-exertion or detriment to health, to produce an increased output.

Scientific Management does not stand for either of these fallacies, of which ignorance is the root, selfishness and short-sightedness the branches, and distrust and animosity the fruits. No individual can hope to derive any permanent benefit from following a course of action that is detrimental to his fellow men; and, conversely, the individual is sure to be benefited by following a course that benefits society.

It has been contended by those opposed to Scientific Management — by employers as well as by workmen — that it deprives the workman of his individuality; robs his chief assets of their value — his skill and traditional knowledge. Let us look into the soundness of this contention.

Manual skill is at least equally valuable and necessary, and cannot be supplanted. For example, a skilled machinist running a lathe can, when taking a finish cut on a piece of work, nine times out of ten, feed his tool into the work just the right depth to make the piece the size required, getting it right the first time; whereas a less skilful man would be afraid of going in too far and making the piece below size, and consequently would make several attempts — stopping and calipering after each until he got it right or spoiled the job. The skilled man will make fewer mistakes, proceed in his work with confidence, know what to do in an emergency, will require less supervision, and as a result, will turn out more work and save expense, consequently being more valuable under any system than the unskilled.

Under the old type of management skilled men and men possessing latent skill are employed frequently in the performance of work that does not bring skill into use; the result being that they may be paid less than their services would be worth if they were employed constantly on work calling for the exercise of skill. Through proper planning this may be accomplished.

Under Scientific Management there are new positions created, calling for good men possessing judgment, experience and skill, such as gang bosses, instructors, planners, time study men, etc., offering opportunities for advancement that did not formerly exist. These positions are filled from the ranks of the workmen.

As to the workman's individuality and initiative, Scientific Management develops them along right lines with demonstrated facts supplanting rule-of-thumb and tradition as a basis; and it is a fact that in practice these qualities are stimulated rather than restricted.

Even though the best men in an establishment may be selected for the planning of work, they will quite frequently receive suggestions from workmen who may be much less experienced or skilful, that result in savings in time and improved methods. The skilled man possessing initiative contemplates with a critical mind the methods laid out by his brethren in the planning department, and takes pride in his ability to show them something; at the same time he is quick to recognize and accept that which is good.

As to the workman's traditional knowledge, it usually comprises much that is good, indiscriminately mixed with error, both as to methods and means. It becomes the function of Scientific Management to bring together, analyze, and prove the vast amount of knowledge making up the trade, and to add to it. This must be classified, tabulated, and made available, through the planning department, to all men; whereas formerly it was scattered — some in the possession of one man, and some in that of another, and not always available when most needed. *The first great principle of Scientific Management is the establishment of a science in place of rule-of-thumb knowledge.*

Before entering into a description of the Planning Department's functions and mechanism, I wish to make one thing very clear: there is nothing done in the Planning Department that did not have to be done under the old scheme of management by somebody — usually less efficiently, but still it was done. Some of this work was done by the foreman, and much of it by the workman. Some men in the shop were good at planning their work, others were not.

However, even in case all men in a shop were equal to the best man in this respect — say the one who was selected for that reason for a position in the Planning Department — it would still be more economical to do it in the Planning Department for the following reasons:

1. The man in the Planning Department has classified data, aggregating many times the individual knowledge and experience of any one man, upon which to draw in planning the best method.

2. He does the planning far enough in advance so that if any special appliances are found to be desirable or necessary, they may be procured or made by the time they will be needed; whereas if the planning of what is to be done and how, is left to the man on the machine, he must frequently use tools and appliances which he knows are not the most suitable because the right ones are not available; and in some cases, has to abandon the job until tools are made or bought.

Finally, he must do most of his planning and making preparation, in the case of machine work, while his machine is standing idle; whereas, if it is done in advance, in the planning department, the workman and his machine will be turning out product. Indirect expenses, such as taxes, lighting, heating, interest, selling, etc., go on just the same when a machine is standing idle, and add to the cost of the product, consequently there is a distinct gain in having the planning done in advance in a planning department, while the machines are running on other work.

Mr. Taylor states, in his paper on "Shop Management," with reference to the work of the planning department:

> The following is an outline of the duties of the four functional bosses who are a part of the planning department, and who in their various functions represent this department in its connection with the men. The first three of these send their directions to and receive their returns from the men, mainly in writing. These four representatives of the planning room are, the "order of work clerk," "instruction card men," "time and cost clerk," and "shop disciplinarian."
>
> *Order of Work or Route Clerk.*[1] — After the proper man in the planning department has laid out the exact route which each piece of work is to travel through the shop from machine to machine in order that it may be finished at the time it is needed for assembling, and the work done in the most economical way, the "route clerk" daily writes lists instructing the workmen and also all of the executive shop bosses as to the exact order in which

[1] As will be noted further along in this paper, the current practice has divided the functions of order of work and route clerks in a manner slightly different from that here indicated. — Ed.

the work is to be done, by each class of machines or men, and these lists constitute the chief means for directing the workmen in this particular function.

Instruction Card Men. — The "instruction card," as its name indicates, is the chief means employed by the planning department in instructing both the executive bosses and the men in all of the details of their work. It tells them briefly the general and detail drawing to refer to, the piece number and the cost order number to charge the work to, the special jigs, fixtures, or tools to use, where to start each cut, the exact depth of each cut, and how many cuts to take, the speed and feed to be used for each cut, and the time within which each operation must be finished. It also informs them as to the piece rate, the differential rate or the premium to be paid for completing the task within the specified time (according to the system employed); and further, when necessary, refers them by name to the man who will give them especial directions. This instruction card is filled in by one or more members of the planning department, according to the nature and complication of the instructions, and bears the same relation to the planning room that the drawing does to the drafting room. The man who sends it into the shop and who, in case difficulties are met with in carrying out the instructions, sees that the proper man sweeps these difficulties away, is called "the instruction card foreman."

Time and Cost Clerk. — This man sends to the men through the "instruction card" all the information they need for recording their time and the cost of the work, and secures proper returns from them and refers these for entry to the cost and time record clerks in the planning room.

This description of the duties of the principal men in the planning department is so brief, that one not familiar with the organization of an existing planning department does not get a very clear idea of the subject. Indeed, "Shop Management" is so condensed, that few people begin to get much out of it until they have seen actual applications of the things described, and have re-read it several times. Nevertheless, Mr. Taylor's "Shop Management" is the most complete treatise on Scientific Management that exists today; and there has been practically nothing written since that has not already been covered in "Shop Management."

Outside of time keeping and cost keeping, the functions of the planning department may be classified under two general headings, namely: (*a*) Planning how work is to be done; (*b*) Planning when work is to be done.

Under the first heading come

The route clerks.
The instruction card men and time study men.

Under the second heading come

The production clerk, and
The order of work clerk.

In addition to the men performing these functions, we have, acting as auxiliaries to them, recording clerks, balance of stores clerks, foundry clerks, and clerks who write up the numerous detail orders, tags, etc., used in directing the work. The duties of, and impedimenta used by, each of these will be described later in detail.

The question is frequently asked: How many men should be in the planning department in proportion to the number of workmen? To this the answer is that it depends entirely upon the size and nature of each specific business. In some cases two or more men are required for each of the positions enumerated while on others two or more of the positions may be combined. For example, one well-known concern has a shop employing about four hundred workmen, with a planning department composed of only four men, while another, employing about one hundred in its shop, requires a planning force of twenty people. The reason for this being that the first concern referred to manufactures, in its shop, a limited variety of products in large quantities, with infrequent changes in design — in most cases each machine running for months, or at least weeks, on the same job; while the second concern manufactures a great variety of products in comparatively small quantities — much of their product being special and subject to frequent changes in design. In the second concern, each workman, on the average, works on four different jobs per day.

A description of the planning department of the second plant referred to will best serve the purpose of illustration for this article.

In the planning department of the plant in question, we have the following functions — in some cases functions being further sub-divided. They are here given in the sequence that each takes up, ordinarily, the work of planning for a manufacturing order that is entered. Ordinarily, an order passes in turn to each of these men, who performs his work in connection with planning for it; there are cases, however, where several of them may be working on the same order simultaneously — in some plants this is the rule.

A, Production Clerk. *B*, Route Clerk. *C*, Foundry Clerk. (Sometimes called Special Material Clerk.) *D*, Balance of Stores Clerk. *E*, Instruction Card Men. (Including Time Study and Slide Rule Men.) *F*, Route File Clerk. *G*, Order of Work Clerk. *H*, Recording Clerk.

In addition to these there are: the Mail Carrier (who in this instance is also the Tickler Clerk), Stenographer, Messengers, and Time and Cost Clerks.

The Production Clerk is the connecting link between the shop and the sales department. He is the man who furnishes information upon which the sales department bases its promises of delivery, and who is responsible to the sales department for meeting deliveries promised.

Based upon the information he receives from the sales department as to when orders are to be shipped, and upon information from the Balance of Stores Clerk as to what manufactured articles are required for stock, the Production Clerk prepares a schedule or " Order of Work." This is essentially a list of all orders in hand for each department, arranging the orders according to their relative importance, taking into consideration the amount of work to be done in connection with each, and the date upon which it should be completed. There are a number of ways of classifying or grouping the various orders — each developed to suit the needs of different businesses. In the plant being used for illustration, the classes are practically as follows:

CLASS 1. *Emergency Class*, made up, as its names implies, of orders that must take precedence, for one reason or another, over work in any other class.

Orders in this class should be the exception, and may only be placed there with the consent of the manager, or some one else high in authority. In the Emergency Class we would have, for example: the order for getting out special parts for a break-down job; or, assuming that a customer ordered a machine on which delivery was promised in a comparatively short time, and as it neared completion, one of the large castings proved defective and had to be replaced — the work of replacing that casting would come within the Emergency Class.

Work in the Emergency Class receives special treatment from each man. In the planning department, if possible, two or more of the steps of the planning are carried on simultaneously, instead of in sequence; and in certain cases I have known of work being started in the shop as soon as the planning had been completed for the first operation, the planning for the following operations being done while the first operation was in progress. As soon as one operation on an emergency job is completed, the next must be immediately started, even if it is necessary to take some other job, not in the Emergency Class, off a machine before being finished; although, in most cases, this can be planned ahead.

While much more might be said of this phase of the Order of Work, I think the examples given will convey a pretty clear idea of the " Emergency Class " of orders, and how they are handled. This is typical of what Mr. Taylor means when referring to "exceptions," and is intended to call attention to the flexibility of the system. Exceptions of this kind are so frequent in a shop run under the old type of management, as to be almost the rule.

For the sake of economical manufacture, there should be very few orders handled in this manner; and the more efficient the plant is in general, the fewer orders there will be in the " Emergency Class " of the " Order of Work."

CLASS 2. *Tools* or *Appliances* required for work under way, or for maintenance of the Tool Room stock.

Orders for the making or repairing of tools, etc., comprising this class are placed virtually at the top of the list, as it is obvious that unless we have the proper tools we cannot properly prosecute the work on our products.

CLASS 3. *Manufacturing Orders* for products required to fill shipping orders on hand, including any stock parts required for these. This class comprises all orders for products not carried in stock, but which must be made up after receiving the customer's order. This class may be subdivided, if desirable, into

a — Orders on which definite shipping dates have been promised.
b — Orders for which there is abundant time in which to complete them.

CLASS 4. *Orders for Stock Parts.*

CLASS 5. *Orders for Stock Machines.*

Under each of these classes are arranged, in the order of their relative importance, the manufacturing orders that are in progress.

The Production Clerk revises the Order of Work for each department at regular intervals, and more frequently if need arises. It is not only the Production Clerk's duty to lay out the Order of Work, but he must see that it is observed in the drafting room, in the planning department, and in the shop. This he does by daily checking up. For example, he must fix a date for the completion of the drawings, of each stage of the planning, for the delivery of castings, etc., all based upon the date required for the completion or shipment of the order. He must be constantly looking ahead to assure himself of the possibility and probability of each stage of the work being completed in time; and where he sees the work falling behind, must arrange to have the man who is overloaded given extra temporary help.

In the plant which I am describing, there are at times sudden inundations of new and special work, when it is necessary to augment the planning force by bringing in men from the shop — sometimes functional foremen, who are temporarily replaced by men from the machines, and sometimes taking men directly from the machines — these men returning to the shop when they are no longer needed in the Planning Department. At other times the reverse has been true: there has been an abundance of work in the shop and little in the Planning Department, in which event some of the regular Planning Department force are temporarily transferred to the shop.

These shifts from the Planning Department to the shop and *vice versa* of course occur only as a result of abnormal conditions, but every concern should be prepared for them. It is a remarkable tribute to the spirit promoted by Scientific Management, that men can shift from the workman's side to the management's, and the reverse, without suffering in their own esteem or that of their associates; and it is pretty good proof that the point of view of the two sides is coincident. Under Scientific Management, those composing the management are not regarded as possessing any superior endowments that set them above the rank and file.

With respect to work in progress in the Shop, the Production Clerk, in addition to preparing the Schedule or Order of Work, systematically, through the route sheets, progress sheets, and the bulletin board, checks up the progress of work to see that the Order of Work is being followed, and for the purpose of detecting and straightening out things that may have gone wrong. This will be touched upon later in the description of the bulletin boards, route files, etc., and their use.

The practice followed in checking up the progress of orders by an efficient Production Clerk, and the only one that accomplishes the desired results — that of fulfilling promises as to delivery, is the reverse of what the average person would do, viz: he does not start in his daily checking up of the progress of work by first looking up the orders due to be shipped today, or those overdue, and following down his list, but starts at the bottom of his list, with the orders just received, and makes sure that everything necessary to the completion of the order on time is being done; the last order to receive his attention is the one due to be shipped, and as a matter of fact it should be the one that least needs it.

The principal cause of failure to complete orders on time is that little or no attention is given them on this score until the date of shipment approaches. In machine shops a great deal of time is ordinarily wasted in getting drawings and patterns made, and getting materials into the shop. This time *cannot be made up after* the work is started, and the effort to do so results in confusion, decreased efficiency of the plant, and more or less friction among the individuals comprising the organization.

From the foregoing it will be seen that the Production Clerk need not be a man with technical or practical shop experience; although he would, all other things being equal, be benefited thereby. He must, of course, be familiar with the processes of manufacture. His function is to decide *when* things are to be done throughout the plant, and his authority in this matter extends to, and must be respected by, every one in the manufacturing plant, from the manager and superintendent down to the messenger boy and the humblest laborer. He must plan, and transmit to each through the proper channels, information as to what each is to do now, what is to be done next, and what is to follow that; but has no authority to say *how* things are to be done.

The Production Clerk's function has been described first because he is the coördinating factor or connecting link between the other functions and departments.

The Route Clerk. — The work of the Route Clerk is the first step in the planning to take place after all information as to what is to be constructed or manufactured has been procured, and put in working shape. In an engineering or machinery manufacturing plant this information is compiled in the form of drawings and bills of material, and it has been the writer's experience in other lines of industry that there is always some equivalent of drawings; sometimes in the form of specifications, and sometimes samples.

The Route Clerk must be a man with practical shop experience. He must be thoroughly familiar with the shop practice and with the products, must be capable of readily reading drawings or their equivalent, and must have the ability to plan and put in writing — in the form of Route Charts or diagrams — the method to be followed in the manufacture of the products.

He must have data available pertaining to all machines, giving their capacities, their location, etc., such as will enable him to decide which machine is the best for performing any given operation on the work to be done. He must consult frequently with various foremen in the shop with reference to the best methods to be followed in machining various parts and assembling them into groups and machines. He must also consult with the Time Study and Instruction Card men so that the machines to which he assigns work are those that will permit of its being done in the most economical manner, and so that the Instruction Card men may avoid having to work up completely new cards for a job, whereas, if it were assigned perhaps to another machine, they could make use, either wholly or in part, of instruction cards that had previously been prepared for other work of the same character. He must also consult frequently with the Engineering, Drafting, or Designing Department, as well as must the Instruction Card men, so that machines or other product may be designed with a view to the greatest facility and economy in their manufacture.

In a large plant, where more than one Route Clerk is necessary to handle the work, we would have one or more men who were expert in assembling to make up the Route Charts, laying out only the manner in which the parts are to be grouped and the assembling operations, while one or more others, especially qualified, would lay out the various machine operations on each of the parts and compute the quantities of materials required, etc. Others would perform the purely clerical work attached to this function.

In other words, the larger the plant and the more varied the line of work, the more the work is divided up along lines of specialization.

Let us now consider the work of the Route Clerk in a machine shop, — representing perhaps the most complex problem, from which the reader who is interested in other lines of manufacture may also form an idea of the application of this function in his own business.

It is the duty of the Route Clerk to take the drawings that have been prepared by the Engineering Department, and, in the case of a machine, analyze the construction of the machine, first splitting it up into groups of parts that can be assembled together independently of the rest of the machine; deciding the relative order of importance of these groups, taking into account the length of time it will require to get the castings and other parts that must be made especially for the order; the amount of work on the various parts, as well as in assembling them; and the stage in the final assembling at which each one of them will be required. This he lays out in the form of a diagram.

He next takes each one of the groups, and lays out a diagram or route chart showing, in the order of their relative importance, all of the parts that are to be made especially for the order, and the operations to be performed upon each of them; their proper sequence; and the machines in which the various operations are to be performed. He also indicates the quantity and kind of material required for each part, indicating whether it is to be purchased or made especially for the job, or whether it is to come from stores. He also indicates what parts, if any, are to be drawn in a finished condition from worked material stores. These he shows in the order of their relative importance, and assigns to each one a mnemonic symbol in accordance with his classification, which serves the purpose of identifying it as it progresses through the shop; indicates what part of the machine it goes in; as well as serving as an operation order number and an index to the instruction cards for each of the several operations to be performed. The symbol also is used in connection with the cost keeping system, and filing any data pertaining to the piece that it represents. The Route Clerk also has made up by a clerk the route sheets and progress sheets upon which the progress of work through the shop is to be recorded, as well as the various Operation Orders, Inspection Orders, Stores Issues, etc.

The Route Charts or diagrams described might be called graphic bills of material, showing as they do not only each part entering into the construction of the machine or article to be manufactured, but also which parts go together, and how they are to be put together and the operations that must be performed on each preparatory to their being put together, as well as the number of each part required and the kind and quantity of the materials from which the parts are to be made. These charts vary from a very simple one for an article composed of three or four pieces, to a complicated one, say, for a locomotive, which would consist of perhaps twenty large sheets. In the case of single pieces to be manufactured, no route chart is of course required, a simple route sheet serving the purpose in such cases.

Foundry Clerk (or Special Materials Clerk). — The man filling this position need not be a mechanical man, as the position is purely clerical. He should, however, be a live wire, as it devolves upon him not only to order certain materials, but to see that they are gotten into the shop as required.

In many lines of industry there are certain materials that are not carried in stock, but are ordered from outside parties specially for the order on which they are to be used. Castings are typical of this class of materials in the case of many machine shops which do not operate their own foundries.

To take care of such materials is the duty of the Foundry Clerk. He maintains the pattern records showing where each pattern is; whether in the pattern storage or at a foundry; when sent to the foundry and when returned, etc. He prepares detail orders on the foundry for all castings required, giving the foundry all necessary information, has the patterns delivered, prepares for the foundry an order of work to guide them in the matter of which castings are wanted first, etc., and follows them up to see that the order of work is followed.

Under the old system of management one of the greatest obstacles to economical manufacture is piece-meal deliveries of castings called for in a lot. If twenty castings are wanted of a certain pattern, the foundry makes them as suits its convenience, and delivers them to the machine shop in driblets — two to-day, one to-morrow, five a few days later, and so on. This makes it difficult to keep track of them, and results frequently in the foreman, when he is hard pressed for a job for a workman, letting him start on the few delivered, making several " bites at the cherry," with the resultant loss of time spent in setting up the machine and tearing it down, where once should suffice. In many shops, as a result of this, there can be found lying around in corners and under benches, a lot of castings representing cases in which the foundry has delivered in excess of the number required, while in other instances, part of a lot of machines will stand around unfinished after the rest of the lot to which they belong has been completed and shipped, waiting for the foundry to deliver the balance of certain castings which they have forgotten.

This cannot happen under the Taylor system, as it is the duty of the Foundry Clerk to specify the quantity of each casting to be delivered in one lot, when the lot is to be delivered, and to accept from the foundry no more and no less than the quantities specified. The analogy to the foregoing will be found in almost any line of industry.

The Balance of Stores Clerks. — Under the Taylor System it is the practice to keep in the Planning Department, "Balance Sheets" or running inventory sheets showing for each article carried in stock: (*a*) The quantity on hand; that is, actually carried in stores. (*b*) The quantity on order but not yet received in stores. (*c*) The quantity required for orders for shipment or manufacture to which they have been apportioned, but not yet issued. (*d*) The quantity available for future requirements. This information is constantly needed in connection with the planning of work.

Orders on the storeroom (stores and worked material issues) are made out for all of the various materials or parts carried in stock — as soon as determined by the Route Clerk from the drawings and bills of material and shown on the route charts and route sheets — and for articles from stock called for by shipping orders (customers' orders) immediately upon receipt of the order.

It is the Balance Clerk's duty to apportion in advance the materials called for on these issues, and subtract them from the quantities available.[1] After having drawn down his balance available, he compares it with his minimum quantity shown at the top of the sheet. If the balance available is in excess of the minimum quantity, that ends the transaction; but if it is less than the minimum, he must issue an order for the quantity indicated for replenishment. This he does, in the case of purchased articles by a requisition on the Purchasing Agent, or, in the case of worked materials by issuing a manufacturing order. The quantity to be ordered is also shown at the head of the Balance Sheet.

When an order has been issued for the replenishment of stock, he enters the quantity in the column showing materials ordered, adding it to the previous balance, and similarly adds it in the column showing the quantity available.

[1] It must be clearly understood that "quantities available" means available for apportionment or reservation only and not for issue. — Ed.

The minimum quantity is so set that materials will be received before the quantity in stores is exhausted, and hence may be considered available as soon as ordered; consequently the balance ordered, plus the quantity on hand, minus the quantity apportioned, equals the quantity available. Likewise the sum of the balance ordered and the balance on hand, as shown in their respective columns, should equal the sum of the balance available and the quantity apportioned. This is a check on the accuracy of the entries.

In arriving at the proper minimum quantity for each article we must take into account the length of time it takes to get the articles, and the rate of consumption.

Fixing these minimum quantities properly in the first place, and their revision to meet changes in conditions is very important, and changes should not be made without the approval of some one competent to judge the advisability of the change. It should be the Balance Clerk's aim to keep his stock down as low as is consistent with economical purchasing, and at the same time avoid not having materials on hand when wanted. He must also keep the designing department and the Route Clerk advised as to any materials on hand for which the demand seems to have ceased, so that they may be used up if possible, and he should be consulted frequently by these parties so as to avoid calling for materials that may not be regularly carried in stock where something equally suitable is on hand.

In the event of materials not being available at the time of apportionment, the Balance Clerk on their receipt notifies the proper party in the Planning Department (the Recording Clerk) that the work in connection with which they are to be used may be started.

Each day the storeroom sends to the Balance Clerk the stores issues for materials that have been taken out of stores. These he sorts by their mnemonic symbols into piles, so that their arrangement is the same as that of the Balance Sheets on his files, using for this purpose, where the number of stores issues is sufficient to warrant it, a special sorting tray commonly called a "flying machine."

After having sorted his issues he enters each one on its proper sheet in the column for materials in stores, subtracting it from the balance previously on hand, and also enters it in the column showing materials apportioned, subtracting it from the balance there shown, and checks off the entry made at the time the materials were apportioned. The total or balance in this column should be the sum of the unchecked items.

There are some exceptions to the rule of apportionment in advance — in general things to be secured from stores immediately after the issue is written — and in such cases the quantity issued must be subtracted from the quantity available. In the case of most office supplies and some shop supplies, it is the rule not to apportion materials, and in such cases only the columns for materials on hand and materials ordered are used.

Upon receipt of materials in stores the Storekeeper notifies the Balance Clerk on forms provided for the purpose, and entries are made in the columns showing materials ordered and materials on hand, subtracting the quantity received from the balance ordered, and adding it to the balance on hand.

The Balance Clerk is responsible for keeping the Production Clerk advised as to stock parts that are running low, and for the accuracy of his sheets; in this connection he must devote a certain amount of time each day to checking up his balance with the quantities shown on the bin tags and the quantities actually in the bin.

The foregoing is, of course, only a general outline of the Balance Clerk's duties, intended to give a good general idea of them.

The unique features of this element of the System are: keeping the stores balance sheets in the Planning Department instead of in the store room, as is customary under the old style of management, and the apportionment in advance and subtracting the quantity apportioned from the quantity available, issuing as a result, orders for the replenishment of stock when the quantity thus shown to be available for future orders falls to the established minimum instead of when the quantity actually in stock is drawn down to a minimum without regard to the requirements for other orders under way in the shop which do not happen to have been called for, but which may be called for at any minute. As a preventive against awkward and costly delays, the value of apportionment in advance will be obvious to the reader.

The writer recalls, some years ago, when he was the superintendent of a plant manufacturing steam engines, after several experiences of not having on hand certain fittings when they were wanted, making a practice each time an order was received to build an engine, of going to the storeroom with a list of all the parts to be drawn from stock for the order in question, finding out how many of each there were in stock, and then going around the shop to each engine being erected and finding out which ones had their parts issued to them, and which had not, subtracting the quantities required by those for which the parts had not been drawn from stock from the quantities in stock, thus finding out laboriously, at the expense of time that could have been more profitably employed, whether or not the parts required were available for the new order. With the system of apportionment that has been described, in connection with a routing system, this is automatically done by a clerk, leaving the superintendent and foreman free to devote their time to more important matters. The question of material being on hand when required should not concern them at all.

Mnemonic Classifications.— The balance sheets must, of course, be so arranged and indexed in files as to facilitate finding quickly the sheet for any article when information is desired, or when entries are to be made thereon. This is accomplished with the aid of mnemonic classifications for " stores " or purchased articles, and for " worked materials " or manufactured articles.

As has already been pointed out in discussing the duties of the route clerk, these classifications serve also certain purposes in connection with that function, and in directing and keeping track of work in progress in the shop. They likewise are followed in arranging the bins in the storeroom — the symbol not only indicating the article but its location in the storeroom as well — and offer a means of indexing the route sheets on which the progress of work in process is recorded, so that when information is desired of any particular piece in any particular lot of a given kind of machine in progress, the sheet on which such information will be found may be turned to and the information obtained without delay. The same thing is true of recording the progress of work at each stage, and ascertaining the next step to be taken and issuing the necessary orders for it.

The same classifications afford a means for sorting time cards, "stores issues," etc., for entry on cost sheets, and for bringing together under various headings information, expenses, and data of various sorts pertaining to the product, methods of manufacture, and accounting. The "mnemonic symbol" system is, in fact, an important element in the mechanism for the application of the principles of Scientific Management, and one without which any system developed for that purpose would be greatly handicapped.

This subject: classification, its basic principles, and the ends it serves, is so large that a book might well be written on it, and it cannot be entered into at any great length here, but a few brief remarks may serve to give the reader a fairly clear general idea of how such classifications are made up.

The first principle of this system of classification is, as in the Dewey decimal system, so generally used in libraries, the grouping of the things to be classified first into broad generic classes. A letter is selected, one that is mnemonic if possible, to designate each class. Next, each of these classes is divided into smaller classes, each of which is designated by an additional letter that is suggestive of the thing it represents, and these sub-classes are still further divided and designated by an additional letter, and so on down to the smallest unit in a class, each letter qualifying or indicating a subdivision of the class or thing indicated by the letter preceding it. Figures are introduced into the symbols in various ways to serve certain purposes, as will be indicated by illustrations which follow.

Let us consider that we are working up a classification for a large manufacturing concern whose product covers a wide range of machinery, including machinery for the generation and transmission of power, metal-working machinery, wood-working machinery, road making machinery, and certain other miscellaneous products. The classification in question is intended to be used in connection with the company's accounting and cost keeping, its routing system, its stores system, and certain other purposes.

We shall, as is customary, reserve the letters A to F inclusive to designate the several broad classes of indirect expenses, and the letters X, Y, and Z to designate the company's building, machinery and other equipment accounts, leaving the letters G to V inclusive (omitting S, which is to be used for stores or purchased articles, and I, J, O, and Q on account of their resemblance to figures and the consequence of their being confused with figures that may be introduced into our symbols) to be used in designating the several broad classes of the company's products which we would classify as follows:

A —		Indirect Expenses	
B —		Indirect Expenses	
C —		Indirect Expenses	
D —		Indirect Expenses	
F —		Indirect Expenses	
G —		Product	Direct Expenses
H —		Product	Direct Expenses
K —		Product	Direct Expenses
L —		Product	Direct Expenses
M —	Machine Tools (Metal-working)	Product	Direct Expenses
N —		Product	Direct Expenses
P —	Power-Generating and Transmission Machinery	Product	Direct Expenses
R —	Road-Making Machinery	Product	Direct Expenses
T —		Product	Direct Expenses
U —		Product	Direct Expenses
V —	Various Miscellaneous Products not otherwise Classified	Product	Direct Expenses
W —	Wood-Working Machinery	Product	Direct Expenses
X —		Plant and Equipment	Direct Expenses
Y —		Plant and Equipment	Direct Expenses
Z —		Plant and Equipment	Direct Expenses

Each of these classes of machinery would then be subdivided into the various kinds of machines of which it is composed. For the purpose of illustration it will suffice to carry out the subdivision for one of them. Let us take Class M — Metal-working Machinery.

M A —	M N —
M B — Boring mills	M P — Planers
M C —	M R —
M D —	M S — Shapers
M E —	M T —
M F —	M U —
M G —	M V —
M H —	M X —
M K —	M Y —
M L — Lathes	M Z —
M M — Milling machines	

Each of these would again be subdivided into the various groups of parts making up the machine. Thus, in the case of lathes, M L B might indicate the bed group, M L C the carriage group, M L H the head stock group, etc.

The Carriage Group might be split up into M L C A indicating the Apron division of the carriage group, M L C C the Cross Slide division of the carriage group, and M L C 1 C would indicate the first piece in that division of the carriage group. The size of the lathe would be inserted in the symbol between the first and second letters, thus: M 20–72 L would indicate a 20 in. lathe with a 72 in. bed. Figures to indicate operations to be performed are prefixed to the symbol, thus: 5 M 20–72 L C 2 C would indicate the fifth operation to be performed in machining the second piece in the cross slide division of the carriage group of a 20 in. lathe with a 72 in. bed. At the end of the symbol we would add a number to indicate the particular lot to which this part belonged.

It will be seen that neither figures alone nor letters alone could be made to adequately serve the several purposes for which the symbol is designed.

In developing this system of classification, which in its present form represents a long process of evolution, as indeed does the entire Taylor System, Dr. Taylor tried first using figures alone, then letters only, neither of which completely met all requirements, and finally settled upon the combination of the two such as has been briefly described above.

Time Study and Instruction Card Man. — The man filling this function must also be a practical shop man, and one who appreciates the importance of minute details. It is his duty to: 1. Make such elementary time studies as may be necessary in order to ascertain the best method to be followed in the performance of each class of work. 2. To prepare instruction cards indicating the method to be followed in performing each operation, what tools to use, etc.

This function was described at considerable length by the writer in an article entitled " Elementary Time Study as a Part of the Taylor System of Management," published in the Feb., 1912, issue of *Industrial Engineering*, to which the reader is respectfully referred.

The Route File Clerk. — In connection with the route sheets for each article to be made and each operation on each route sheet, there are several pieces of paper to be filled out: an order on the storeroom for the materials from which the article is to be made; a tag to be attached to the lot of parts; an order for each operation, for the inspection that takes place at the start of each operation as an insurance that the operator understands the requirements and gets started right, for the inspection of the work done on the lot of parts at the completion of each operation, for moving the material from the storeroom to the machine that is to perform the first operation, and for moving the parts from a machine where an operation has been completed to the machine in which the next operation is to be performed.

If the writing of these operation orders, etc., was left until they are needed, it would result in such delay and confusion that the whole scheme would fail to work, and even if it could be made to work, the expense of doing it that way would be prohibitive.

All of these pieces of paper for a given article or unit contain, with the exception of the operation number, the number of the machine or work-place where the operation is to be performed, the time the operation should take, and exactly the same items of information, consisting of the order number or symbol to which the article belongs, the piece symbol, the number of pieces in the lot, the drawing number, etc.; and consequently a duplicating machine, either of the " hectograph type " or the multigraph can be used to good advantage. Which type of duplicator should be used depends upon how many copies are required from the same writing; this varies in different types of industries.

It is the duty of the route file clerk, or operation order clerk, as he is sometimes called, to prepare all of these written orders required by the route sheets. In a sense this might be regarded as a subdivision of the route clerk's function. The operation orders, etc., are placed by the route file clerk in a receptacle known as an " envelope sheet " or an equivalent of the same, and placed in the route file, where they will be conveniently at hand when wanted.

To most people it would perhaps seem unlikely that there should be any science in the performance of this function, and yet it is surprising to find how much there is in so apparently simple a thing as the use of a duplicator of the " hectograph " type for making up operation orders. A careful study of this proved that under properly standardized conditions, with standardized implements and appliances, and following the method developed as a result of the study, a clerk could handle more than twice the amount of work that he could when left to follow the course indicated by his " initiative." This is true of almost all clerical work.

The Order of Work Clerk. — The man performing this function need not be a shop man, that is, he need not be a mechanic, although he should be familiar with the work and the plant. His function is to administer the " Order of Work " for the shop through the medium of the " bulletin board."

He must see that the various jobs (operation orders) ahead of each machine are taken up and performed in accordance with their relative importance, deciding, as each new job arrives at a machine, whether it is to be done next after the job under way, or whether it is to be the third, fourth, or fifth job. In deciding this he is guided by the " Order of Work " or schedule furnished him by the production clerk.

Where there is not enough work to keep certain machines running steadily, he decides when to transfer men to them as work accumulates. To do this intelligently, he must know what kind of machines each workman can operate, and the grades of work each is capable of doing. This information he must secure from the various foremen and inspectors.

It is his duty to see that each man has at all times laid out ahead of him a proper amount of work (usually at least ten hours of work), and to notify the proper person (usually the superintendent) in case he cannot get work enough for the men, or in case there are not enough men to handle the work so that orders will be completed when due.

The " bulletin board " referred to is a most important piece of Planning Department machinery, of which there are a number of forms. A description of one of these forms will, however, suffice, as the differences are merely of construction and not of principle.

On the bulletin board under discussion there is a set of three hooks, one under the other, for each machine or work-place in the shop. On the first of the hooks is hung the operation order for the job in progress on the machine, and a tag showing the name of the workman on the machine. On the second hook are the operation orders for the various jobs that are at the machine waiting to be done; these are arranged in the order in which they are to be taken up by the operator. Duplicates of these orders are also shown on a bulletin board in the shop conveniently located to the machines, to which the gang boss and the workmen refer for information concerning their work. On the third hook are hung the operation orders for jobs ahead for the machine which are in progress in the shop, but which have not yet progressed to the machine in question; that is, they are at some other machine to have operations performed that precede the one represented by the order on the third hook.

From this it will be seen that the order of work clerk has a " bird's-eye view " of what is going on in the shop, what work is ahead of each machine, and is able to plan the work much more intelligently than can the foreman under the old style of management, who depends upon his memory and upon observation for keeping track of and laying out his work. Any one who has worked as a foreman under the old style of management will realize how difficult it is to keep a gang of men supplied with work and to be sure that each man is working on the job that is of the greatest importance.

The order of work clerk is constantly and systematically going over the bulletin board, seeing which machines on which workmen are working are running short of work, which machines to which no men have been assigned have work ahead that should be started, what men will be available by reason of all the work ahead of them being finished and how soon, that an important job is not waiting while one that is less important is being worked on, etc.

Lost time between the completion of one job and starting the next is thus avoided, the rule being to have preparations made in advance for two or more jobs (at least ten hours' work) ahead for each workman. If the order of work clerk finds that there is less than this amount of work ahead of a workman on the machine he is at the time operating, he first sees whether there is any more work that can be gotten to the machine in question in time to keep it going. If not, he next ascertains to what other machine, idle at the time, but at which there is work waiting to be done, the workman may be most advantageously transferred, and arranges for doing so, indicating the same by a notification slip, similar to an operation order on the hooks for the machine from which the man is to be transferred and the machine to which he is assigned. Duplicates of these slips are, of course, placed on the shop bulletin boards for the guidance of the workman and the gang boss.

The bulletin board is also used as a guide in sending out to the machines the drawings, instruction cards, and tool lists in advance of the time jobs are to be started, so that preparation for each job may be made. When a workman finishes his last job on a given machine, or is for any other reason transferred to another, when he goes to the machine to which he has been assigned he will find everything ready for him to start work without loss of time; his drawing, instruction card, etc., having been delivered and his tools procured from the tool room.

The Recording Clerk. — As has been already explained, route sheets, one for each lot of parts or unit composing an order, are made out by the route clerk. These indicate the symbol of the part or unit, the quantity in the lot, the drawing number, and such other general information or description as may be necessary, and specify the operations to be performed in their proper sequence and the machines in which each operation is to be performed. These sheets are placed in files which are also receptacles for the instruction cards, tool lists, operation, inspection, and move orders pertaining to the operations indicated on the route sheets, all of which are written up in advance so that there will be no delay at the time they are required. On the route sheet each step in the progress of the work to be done on a lot of parts is indicated, so that what has been done and what remains to be done is always evident. Its function is not, however, merely to record history, but to indicate what each succeeding step is to be, and when it is to be taken. They are the recording clerk's guide in performing his function, which is to record the progress of the work, to issue and receive operation orders, inspection orders, move orders, etc., at each stage in the progress of the work.

To illustrate: A workman finishes a job and hands in to the recording clerk a finished time card, and the recording clerk does the following things:

(*a*) Takes from the bulletin board the operation order for the job just finished, and turns it over to the order of work clerk to have the shop copy recalled from the shop bulletin board.

(*b*) Ascertains what the workman's next job is (from the next operation order on the bulletin board), and gets the time card and first inspection order for it from the route file, checking the route sheet to show that the operation has been started, and that the inspector has been notified.

(*c*) Stamps the time on card just received and the one being issued, and delivers the time card for the new job to the workman.

(*d*) Sends inspection order (for first inspection on job being started) to inspector.

(*e*) Opens route file for job reported finished, and checks it to show that such is the case. Takes out " final inspection " order, checks route sheet to show inspection ordered, and sends the inspection order to inspector.

(*f*) Has the "drawing boy" take out to the machine the drawing, instruction card, and tool list for the next job following the last one for which they have been issued, and bring back those for the job just finished.

When inspection orders are received showing the final inspection made, he issues a move order for moving the job to its next destination, and checks the route sheet to show that it has been done.

When a "move order" is returned showing that work has been moved, he issues the operation order (through the order of work clerk) for performing the next operation on the job in question.

The functions of the time and cost clerks have not, owing to the magnitude of the subject, been taken up. The accounting system developed by Dr. Taylor and those who have been associated with him is, perhaps, at the same time the most complete and the most simple that has ever been devised, giving all essential information accurately and in the most useful form with a minimum of labor. This feature of the Taylor System fits in with the other elements making use of the mechanism used and work done in connection with planning the work and running the plant. A book could well be written on this interesting and important phase of the system.

Many people have, in the past, made the mistake of overestimating the importance of cost systems, and without first laying the foundation for them, and at the same time doing those things necessary to economical manufacture, have undertaken their installation. In such cases the result is returns so inaccurate as to be not only valueless, but misleading, or at best indicating what might be taken for granted, that things cost too much. Accurate means of measuring work done are, of course, a prime essential to any cost system, as well as for measuring the efficiency of the work, and yet frequently manufacturers will spend good money in attempts at cost keeping with such slipshod methods for securing returns as to render the results worthless. By a measuring of work the writer means determining definitely, as is done in the routing system described, the point at which one operation ends and another starts, providing reliable means for the recording of the time of starting and of completion and checks against time that has been spent on one job being charged to another. The chief value of a cost system is a check upon results. As a means of lowering costs or increasing output it is, to a great extent, similar to the practice of " locking the barn door after the horse is stolen." For these and certain other reasons the cost system is usually the last thing taken up in installing the Taylor System, although the way is paved for it incidentally almost from the start.

In conclusion the writer wishes to emphasize certain points:

1. That in writing this article it has been his object to amplify certain things in connection with the practical application of the principles of Scientific Management that have already been covered in a less detailed manner by Dr. Taylor in his books *The Principles of Scientific Management* and *Shop Management*, and that unless the reader has already read and studied them — acquiring thereby a knowledge and understanding of the basic principles of the science of management — he will derive little good from reading this article, which is merely intended to give a better idea of the mechanism for the application of the principles and its working. Again, it may not be out of place to warn the reader against the danger of mistaking the " form for the substance."

2. That in describing the various mechanisms of the system — the functions of the Planning Department, etc. — it has not been possible to go into sufficient detail to cover every feature or every element of the features described, but merely to afford the reader such a bird's-eye view as one would get as a result of a day's visit to a plant in which the Taylor System is in operation, and having it explained by some one conversant with it.

3. The mechanism described must not be regarded as being universally applicable. Every industry and every shop presents different conditions and different requirements, to meet which variations in some or all of the elements must be worked out by the engineer directing the development of the system. The principles remain the same, but the method of application differs.

THE FOREMAN'S PLACE IN SCIENTIFIC MANAGEMENT

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WHAT is "functional foremanship"? This expression has appeared much of late in the various articles on Scientific Management, and as it apparently plays an important part in discussions of that subject, a detailed explanation is in order. The institution of functional foremen, as opposed to the usual single individual commonly known as "the boss" in industrial plants, is probably the most radical change that Scientific Management makes when it undertakes the reorganization of an industry. For, with the installation of functional foremen, a planning department automatically comes into existence, and the separation of the planning of methods of doing work from the doing of the work itself is immediately accomplished.

Functional foremanship means the splitting up among several individuals of the duties usually discharged by a single foreman. Each of these individuals is a specialist in the particular line to which he is assigned, and is trained to the highest efficiency in discharging the particular duties of that line. The work of each specialist, or functional foreman, supplements that of the others, and their duties are so clearly defined that none ever interferes with the other foremen.

In order to more clearly understand the difference between the operation of a plant under functional foremen and one run on the older plan of having a single foreman with a multitude of duties, let us imagine a case in a plant making a general line of machinery, where usually every job is different from every other one. We choose a case of this character because it has often been argued by uninformed persons that Scientific Management, as it is generally understood, might easily be applied to a manufacturing plant where processes were repetitive, and thousands of duplicate parts are made, but that it would be a very different proposition in a shop doing a variety of work and where no two operations are the same.

Consider then a room in a shop, equipped with lathes, planers, drills and other machine tools, and presided over by a single foreman, responsible for the work of say 30 men. Among these men are half a dozen, Morgan, Brooks, Smith, Johnson, Sweet and Flannery. The foreman is at Johnson's lathe, supervising the production of a rather difficult and important piece of work, which has to be made very accurately, and on which the foreman must see that no mistakes are made. While he is so engaged, Brooks approaches him, and informs him that he has finished the job he was on and that he wants another. The foreman, being much engaged with Johnson, tells Brooks that he will see to him in a minute or two, and continues what he is doing. Brooks stands around or goes over and talks to Sweet until the foreman finishes with Johnson. The foreman then examines the orders which have been assigned to him by the office for the production of work, and gives a job to Brooks. It is a rather complicated job, and requires some explanation. While explaining the work, and discussing the best method of doing it with Brooks, Smith comes up and demands a job. With a hurried "Well, you see how it is to be done," the foreman leaves Brooks, to get a job for Smith. Brooks is not altogether sure that he does see, but rather than say so and further detain his boss, proceeds on his own responsibility, makes a mistake and spoils the piece. It is not evident to him, however, and he continues work; and the foreman, being concerned with Smith and worried over the fine job in Johnson's lathe, does not get to Brooks for a long time. Consequently Brooks' work is not inspected and the error is not discovered until a lot of time and money have been wasted, which would have been saved had the foreman not been so busy.

Meanwhile the foreman has found a job for Smith. It is the machining of half a dozen large castings, and the office has indicated that it expects these to be done on piece work. It is a new job in the shop, and the foreman and Smith haggle a while over what is a fair rate. Neither one knows just how long it should take to finish one casting and a considerable discussion ensues, but finally a compromise is reached, although each thinks he has been "stung." The foreman then tells Smith that Flannery had brought the first casting in the day before and put it at the big planer where it was to be machined, and goes back to Johnson. Smith fails to find the casting, and once more goes to the boss. He assures himself that the casting is not at the planer, and, not seeing Flannery around, the two spend a lot of time hunting until they find the casting at one of the milling machines where Flannery had put it by mistake.

And so it goes on all day. The foreman is at the beck and call of all the men, showing them how to do their work, discussing methods with them, assigning work, fixing piece rates, pushing rush orders through, hiring men, firing or disciplining others, keeping the men busy all the time as far as possible, seeing that they do not soldier, keeping track of new work, and attending to a multitude of other duties too numerous to mention.

To perform all these duties completely and well, and not to neglect a single one, he must possess about ten qualifications which are seldom or never combined in one man. He must have brains, education, technical knowledge, patience, tact, nerve, energy, honesty, judgment and good health. A man with all these characteristics would be too valuable to be a foreman, and if he could be found would probably occupy the position of works manager or general superintendent. The picture outlined above is one that can be seen at any time in hundreds of shops on a busy day, and the various incidents related not only cut down production, but run up charges due not only to the wages paid idle men, men who are waiting for the boss, but also to the much heavier overhead charges on machinery and plant, which go on all the time, whether tools are working or idle.

Let us now see how the same plant would be run under functional foremen. We will assume that the full number — eight — recommended by the best authorities on management, are employed, that each one is thoroughly instructed in his duties, and that there are available for those that need them, records and time studies of, at least, all the important jobs and operations in the shop.

The various functional foremen are known as Route Clerk, Instruction Card Man, Cost and Time Clerk, Gang Boss, Speed Boss, Repair Boss, Inspector, and Disciplinarian. Of these, the first three are in the office or planning room. The next four are in the shop, while the disciplinarian may spend his time regularly in either shop or office.

In its course through the shop a given job will pass through the hands of these men in the following order: route clerk, instruction card man, gang boss, speed boss, inspector, time and cost clerk. The repair boss and disciplinarian are not directly concerned with production and their functions are indicated by their titles. Their duties will be discussed in detail later on.

The order, drawings and bill of materials for every job that is to be done in the shop come first to the planning room. The necessary castings, forgings and other parts are ordered by a stock clerk either from stores or other departments of the plant or are ordered purchased from outside. The raw material being provided for, the job is placed in the hands of the first of the functional foremen — the route clerk. This man should have a knowledge of machine work sufficient to enable him to devise promptly from the drawing the best method of doing a given piece of work, as whether a surface had best be milled or planed, or whether a cylinder could best be bored in a lathe or a boring mill. He also must be able to read drawings clearly, and have sufficient imagination to make from the drawing a mental picture of the finished work.

To this man first, then, comes the drawing and bill of materials or other specifications according to the custom of the plant. He makes a study of the job and decides on the best methods to follow in doing it. He not only decides on the operations necessary but the exact sequence in which these operations should be performed. Furthermore, the route clerk should be armed with such information in regard to the equipment of tools in the shop that he can indicate on his route sheet the particular tool or group of tools in which each operation is to be performed. After having determined these things, the route clerk will make a list showing the course of the piece through the shop, the machines at which it stops, and the sequence of operations at these machines. In addition to routing the individual piece, as above described, the route clerk daily issues a list of work to the shop showing the order in which the various jobs are to be performed by every class of machine or men.

After the route sheet on a piece is prepared, it goes to the instruction card man. This man should be an expert in machine work, and should be able to devise methods of doing new jobs which are quick, accurate and economical. He should also have at his command time studies of fundamental operations, such as the length of time required to turn the face of a cylindrical surface of a given length, using a particular feed and speed, the length of time to face a hub of a certain diameter, the time required to plane a flat surface of a given area, etc. The instruction card man will study the drawing and route sheet, and from these studies will prepare detailed directions for the performance of each operation. He will write the directions in language that cannot be misunderstood, on a card, adding, if necessary, sketches to make his meaning clearer. He will detail on the card the tools to use, how they are to be set, the feed to use, the speed of the machine, the depth of cut, the method of setting and clamping the work in the machine, the sequence of minor operations at each tool, etc. In fact, he will tell in advance the story of doing the work. If such records are at his disposal, the instruction card man will prepare these instructions from standards already established, or from records of previous similar jobs. Also, if time studies have been made in the shop, the instruction card man will indicate opposite each operation the length of time which a good workman should not exceed in doing that operation. But even if time studies have not been made, and there are no records of unit times available, the institution of an instruction card man to devise methods of doing work is a long step in advance of doing work by the usual scheme of having a single foreman to supervise and instruct all the men at the same time. After instruction cards are prepared, the order is transmitted to the shop. The method of transmission is immaterial to the purpose of this article.

The job in the shop comes under the direction of the gang boss, the speed boss and the inspector, each having a distinct function or set of duties to perform, and each carrying out these functions independently of the other men. Probably their duties can best be explained by taking a hypothetical case and following the job through the hands of the three foremen. Let us assume the job to be done is the planing of a milling machine table.

The gang boss will know in advance, by means of the order of work sent him by the planning department, on which planer the table is to be machined, and in just what order, in reference to the other work of the shop, it is to be done. Before the previous job in the planer is finished, the gang boss will ascertain from the route sheet of the milling machine table, the location of the casting, and he causes it to be moved to the planer by a laborer in advance of the time it is needed.

He also learns from a tool list furnished him by the planning room the planing tools needed, the number, size and shape of straps required to hold the table on the planer bed, the number and size of bolts required for the straps, the number and size of blocks for the outer ends of the straps, the pins and wedges and other fastening appliances which will be needed, and also all of the gages which will be required in the measuring and setting of the bed. The gang boss will have the tool room get these tools together, and before the man at the planer is ready for them will have them sent to his machine. The machinist, finishing the work in hand, will learn from a bulletin board or other source of information that the milling machine table is his next job, and alongside of the planer he will find the casting and also the necessary tools. He will immediately proceed to place the work in the machine, following the directions on the instruction card which meanwhile has been given to him by the gang boss. This official will oversee the putting in the planer of the milling machine table, and will see that it is set up correctly and fastened in accordance with the directions of the instruction card. When he has satisfied himself in regard to these points, the gang boss is done with this particular job until the inspector passes it, when it will once more come under his jurisdiction for movement to the next machine.

The work once in the machine, the speed boss takes charge of it, and sees that the piece is machined in the way laid out by the planning department. He will assure himself that the cutting tools are set correctly, that the feeds, speeds and cuts specified are being taken, and that the workman is proceeding in such a manner that there will be no mistakes made, and therefore no spoiled work. If necessary, the speed boss, who should be an expert machinist, will instruct the workman in the manipulation of his machine, although this should not be necessary on any but new or difficult jobs outside the regular run of work. However, he should be prepared at any time to instruct any workman in methods of machining and to see that they accomplish each operation in the time specified on the instruction card. If the job consists of a number of similar pieces, the speed boss usually remains with the workman until he completes the first one, to assure himself that no mistakes are made and that the man has comprehended the correct methods of doing the job. In case the man fails to complete the work in the time laid down on the instruction card, it is the duty of the speed boss to investigate and ascertain the reasons for this failure, and to remove the causes. If the workman claims that it is impossible to accomplish the job as outlined by the planning room, the speed boss must be prepared to undertake and accomplish the work in the manner and in the time the instruction card calls for.

The milling machine table, after being finished in the planer, would be turned over to the inspector. This official would carefully examine and measure it, to ascertain that it was free from defects, planed to size, and made according to specifications. This man must be honest, and possessed of judgment to know when to reject and when to pass work without insisting on unnecessary refinements. The piece, after being passed by the inspector, once more comes into the domain of the gang boss for removal to the next machine, or to the assembly floor or shipping room, if the last operation has been completed.

The time cards from the men performing the various operations are turned in to the planning room, where they are taken charge of by the time and cost clerk, who computes from them the earnings of the men, ascertains if a bonus has been made or not, providing the shop is on a bonus plan of wage payment, and then distributes the cost of the work to the proper accounts of the cost department. These six men, whose work we have described, are the only functional foremen who are directly concerned with the production of the regular work of the shop. The two remaining functional foremen, while not directly concerned with production, affect it in certain cases to a greater or less degree.

For instance, the repair boss, as his name indicates, is required to keep all the machinery in the shop, including the transmission machinery, in first class condition. He must see that the workmen keep their machines cleaned and well lubricated, that the belts from the countershafts to the machines and from the main line shafts to the countershafts are kept at the proper tension, so that they can always pull the loads imposed by the speeds and feeds required by the planning department. If the shop is run properly, each belt will be taken down at regular intervals, and tested by means of spring balances, to see that it is within the limits of tension required for the best results in power transmission; and, if not, be lengthened or shortened, as the case requires. The whole idea is to anticipate breakdowns and to make repairs before the shop or a machine is shut down by the failure of some part. The repair boss should keep a record of all repairs and tests, such as those of belts, in order that too long an interval may not elapse before that particular piece of apparatus is examined again.

The shop disciplinarian is a man who takes all cases of discipline out of the hands of the other functional foremen. He should be a combination of firmness, tact, and good nature, and be a keen judge of men. He should be a man who understands when the best results will be accomplished by means of a " jolly," or when sternness is a necessity. The functions of this man in relation to the other foremen can be best understood by imagining what might happen with a new workman who had never worked under functional foremen previously. The workman would be assigned to his first job by the gang boss and would be provided with his rough casting and his tools by the same man. In this respect he would not notice anything particularly different from the proceedings in the shop from which he came and which had been under a single general foreman. He would be provided with an instruction card, but might choose to ignore this and to carry out the work according to his own ideas. The speed boss, coming along at this moment, would notice the discrepancy between the instructions and the way the workman is doing the job. He would immediately call the workman's attention to the fact that he was not following instructions and would proceed to show him the correct way of working. It is easily imagined that a workman might resent this interference from one of whom he had no knowledge and who apparently had no particular authority over him. He might partially accede to the speed boss's request or might flatly refuse to follow directions. There would be no argument on this score. The speed boss might, as man to man, inform the workman that it would be to his advantage to follow directions, but, if he did not do so, the speed boss would not attempt to discharge him, dock his pay, or enforce other disciplinary measures. He would simply report the matter to the shop disciplinarian, who would take up the case of the workman, and apply whatever remedial measures might be required. All discharges of men are made by this official, and in many cases the men are also hired by him.

The value of the disciplinarian as a separate official will be evident on a little consideration. The function of the other bosses is to get the maximum amount of work out of the shop. Arguments and the enforcement of discipline may, and often do, engender hard feelings between foreman and workman and reduce the efficiency of both. When these arguments are transferred to a man who has no direct connection with the production of work, the relations of the other men to the bosses are left undisturbed by any discipline that may be visited on any person in the shop; consequently, the working force is maintained at its highest efficiency, regardless of any personal feeling that may exist between the men and the disciplinarian.

We thus see how the characteristics required by an ideal foreman, controlling all the functions of management in a single department of a works, are divided up among a number of men, each of whom possesses certain ones which especially fit him to discharge certain functions but who lacks other characteristics which would enable him to take care of other equally important functions in the management of the department. Thus the route clerk must be a man of foresight, with a general knowledge of the workings of machine tools. He need not, however, be an expert machinist. The instruction card man, on the other hand, must be highly skilled in all the devices of his trade and must also possess ingenuity and have some inventive ability. He need not, however, necessarily be a good executive. The gang boss should have considerable executive ability and should be able to set work in machines to good advantage, although it is not necessary that he be expert in the manipulation of the machine. He should be painstaking, a hustler and have a mind for detail. The speed boss must be an expert machine operator and need not have many of the other qualities. The inspector should be able to read drawings and possess keen judgment as to the quality of work. He should be of sterling honesty and should be of such force of character that he would be unmoved by forceful protests of workmen and bosses over rejected work. The repair boss should be painstaking and neat. The quality of the disciplinarian we have discussed above.

It is thus evident that, although it is almost impossible to obtain in one man all those qualities which go to make up the ideal foreman, it is possible to obtain them in a shop by the system of functional foremanship. Furthermore, even were it possible to obtain a man who would be the ideal foreman, the quality and quantity of work turned out by the shop would be lower than under functional foremen, simply for the reason that one man would not have the time to look after more than a very few workmen.

SLIDE RULES FOR THE MACHINE SHOP AS A PART OF THE TAYLOR SYSTEM OF MANAGEMENT

By CARL G. BARTH

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1. In his paper on "Shop Management," read at the Saratoga meeting of the Society in June last, Mr. Fred. W. Taylor referred to certain slide rules that had been invented and developed under his supervision and general guidance, by means of which it becomes a comparatively simple matter to determine that feed and speed at which a lathe or kindred machine tool must be run in order to do a certain piece of work in a minimum of time.

2. These slide rules were also mentioned by Mr. H. L. Gantt in his paper "A Bonus System of Rewarding Labor" (New York Meeting, December, 1901), as being at that time in successful use in the large machine shop of the Bethlehem Steel Company, and reproductions of a number of instruction cards were therein presented, the dictated feeds and speeds of which had been determined by means of these slide rules.

3. Mr. Taylor early set about making experiments with a view to obtaining information in regard to resistances in cutting steel with edged tools, and also the relations that exist between the depth of cut and feed taken to the cutting speed and time that a tool will endure; and he advanced far enough along these lines in his early position as engineer for the Midvale Steel Company to make systematic and successful use of the information obtained; but as this, of course, was confined to tempered carbon tools only, it was not applicable to the modern high-speed steel, so that the invention and introduction of this steel called for new experiments to be made.

4. These were first undertaken under Mr. Taylor's direction at Bethlehem, so far as the cutting of steel alone was concerned; and later on at the works of William Sellers & Co., Inc., of Philadelphia, at which place the writer spent fifteen months in going

over these experiments again, on both steel and cast iron, and with tools of a variety of shapes and sizes, and for which nearly 25 tons of material were required.

5. However, it is not the writer's intention at this time, to give an account of these experiments, or of the results obtained and conclusions drawn from them, but merely to give some idea of the slide rules on which these have been incorporated, and by means of which a most complex mathematical problem may be solved in less than a minute.

6. He will also confine his attention to the most generally interesting of these slide rules; that is, the slide rules for lathes, and he will take for an example an old style belt-driven lathe, with cone pulley and back gearing.

7. Considering the number of variables that enter into the problem of determining the most economical way in which to remove a required amount of stock from a piece of lathe work, they may be enumerated as follows: —

I. The size and shape of the tools to be used.
II. The use or not of a cooling agent on the tool.
III. The number of tools to be used at the same time.
IV. The length of time the tools are required to stand up to the work (LIFE OF TOOL).
V. The hardness of the material to be turned (CLASS NUMBER).
VI. The diameter of this material or work.
VII. The depth of the cut to be taken.
VIII. The feed to be used.
IX. The cutting speed.
X. The cutting pressure on the tool.
XI. The speed combination to be used to give at the same time the proper cutting speed and the pressure required to take the cut.
XII. The stiffness of the work.

8. All of these variables, except the last one, are incorporated in the slide rule, which, when the work is stiff enough to permit of any cut being taken that is within both the pulling power of the

lathe and strength of the tool, may be manipulated by a person who has not the slightest practical judgment to bear on the matter; but which as yet, whenever the work is not stiff enough to permit of this, does require to be handled by a person of a good deal of practical experience and judgment.

9. However, we expect some day to accumulate enough data in regard to the relations between the stiffness of the work and the cuts and speeds that will not produce detrimental chatter, to do without personal judgment in this matter also, and we will at present take no notice of the twelfth one of the above variables but confine ourselves to a consideration of the first eleven only.

10. Of these eleven, all except the third and tenth enter into relations with each other that depend only on the cutting properties of the tools, while all except the second, fourth and ninth also enter into another set of relations that depends on the pulling power of the lathe, and the problem primarily solved by the slide rule is the determination of that speed-combination which will at the same time most nearly utilize all the pulling power of the lathe on the one hand, and the full cutting efficiency of the tools used on the other hand, when in any particular case under consideration values have been assigned to all the other nine variables.

11. If our lathe were capable of making any number of revolutions per minute between certain limits, and the possible torque corresponding to this number of revolutions could be algebraically expressed in terms of such revolutions, then the problem might possibly be reduced to a solution, by ordinary algebraic methods, of two simultaneous equations containing two unknown quantities; but as yet no such driving mechanism has been invented, or is ever likely to be invented, so that, while the problem is always essentially the solution of two simultaneous equations, or sets of relations between a number of variables, its solution becomes necessarily a tentative one; or, in other words, one of trial and error, and involving an endless amount of labor, if attempted by ordinary mathematical methods; while it is a perfectly direct and remarkably simple one when performed on the slide rule.

12. The slide rule method of solution may, however, also be employed for the solution of numerous similar problems that are

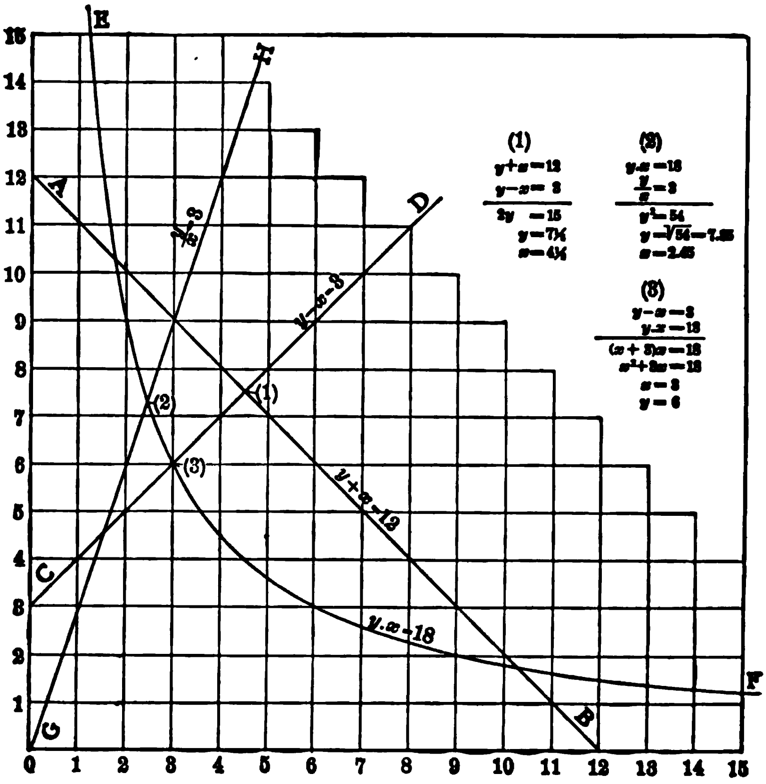


FIG. 3.

capable of a direct and perfect algebraic solution; and it will, in fact, be best first to exhibit the same in connection with the simplest imaginable problem of this kind.

13. In the first place, the solution of two simultaneous equations may be graphically effected by representing each of them by a curve whose coördinates represent possible values of the two unknown quantities or variables, for then the coördinates of the point of intersection of these curves will represent values of the unknown quantities that satisfy both equations at the same time.

14. *Example* 1. Thus, if we have $y + x = 12$ and $y - x = 3$, these equations are respectively represented by the two straight lines AB and CD in fig. 3; and as these intersect at a point (1) whose coördinates are $x = 4\frac{1}{2}$ and $y = 7\frac{1}{2}$, these values will satisfy both equations at the same time.

15. *Example* 2. Suppose again that we have

$$x.y = 18 \text{ and } \frac{y}{x} = 3,$$

and these equations are respectively represented by the equilateral hyperbola EF and the straight line GH; and the coördinates to the point of intersection of these (2) being respectively $x = 2.45$ and $y = 7.35$, these values will satisfy both equations at the same time.

16. *Example* 3. Similarly, if we have $y - x = 3$ and $y.x = 18$, these equations are respectively represented by the straight lines CD and the equilateral hyperbola EF; and the coördinates to the point of intersection of these (3) being $x = 3$ and $y = 6$, these values will satisfy both equations at the same time.

17. The slide rule method of effecting these solutions — to the consideration of which we will now pass — will readily be seen to be very similar in its essential nature to this graphical method, though quite different in form.

18. In fig. 4 is shown a slide rule by means of which may be solved any problem within the range of the rule of the general form: "*The sum and difference of two numbers being given, what are the numbers?*"

19. The rule is set for the solution of the case in which the sum of the numbers is 12 and their difference 3, so that we may write

$$y + x = 12 \text{ and } y - x = 3,$$

which are the same as the equations in Ex. 1 above.

20. In the rule, the upper fixed scale represents possible values of the sum of the two numbers to be found, for which the example under consideration gives $y + x = 12$, opposite which number is therefore placed the arrow on the upper slide.

21. The scale on this slide represents possible values of the lesser of the two numbers (designated by x) and the double scale

on the middle fixed portion of the rule represents possible values of the greater of the two numbers (designated by y); and these various scales are so laid out relatively to each other, and to the arrow referred to, that any two coincident numbers on these latter scales have for their sum the number to which this arrow is set; in this case accordingly 12.

22. The bottom fixed scale on the rule represents possible values of the difference of the two numbers, in this case 3, opposite which number is therefore placed the arrow on the bottom slide of the rule, the scale on which also represents possible values of the lesser of the two numbers, x; and the double fixed scale in the middle of the rule representing, as already pointed out, possible values of y, the whole is so laid out that any two coincident numbers on these latter scales have for their difference the number to which this arrow is set; in this case accordingly 3.

23. Fixing now our attention on any number on the double y scale in the middle of the rule, we first note the values coincident to it in the two x scales on the slides; and this done, we readily discover in which direction we must move along the first scale in order to pick out that value of y which has the same value of x coincident with it in both x scales. For the case under consideration this value of y is $7\frac{1}{2}$, and the coincident value in both scales is $4\frac{1}{2}$. Evidently, therefore, $y = 7\frac{1}{2}$ and $x = 4\frac{1}{2}$ are the numbers sought. (See fig. 4.)

24. In the same manner we may make a slide rule for the solution of the general problem: "*The product and quotient of two numbers being given, what are the numbers?*"

Such a rule would differ from the above described rule merely in having logarithmic scales instead of plain arithmetic scales.

25. By the combined use of both arithmetical and logarithmic scales we may even construct rules for a similar solution of the general problems: "*The sum and product, or the sum and quotient, or the difference and product, or the difference and quotient of two numbers being given, what are the numbers?*" and a multiplicity of others; and the writer ventures to suggest that slide rules of this kind, and some even simpler ones, might be made excellent use of in teaching the first elements of algebra, as they

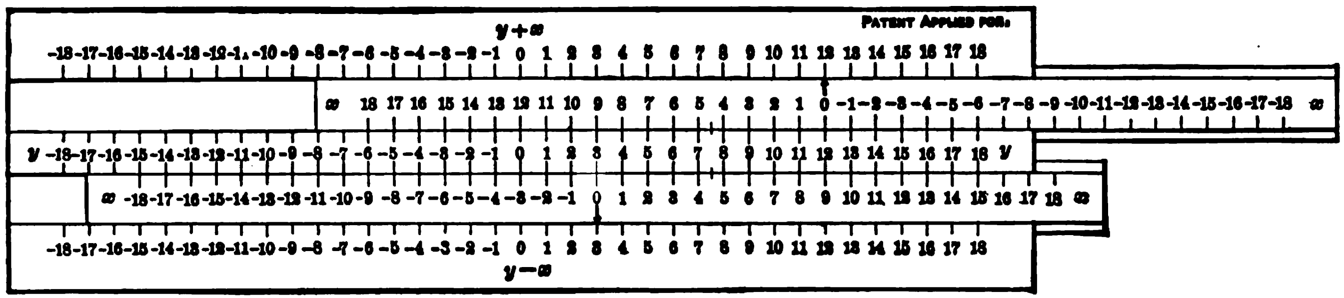


Fig. 4.

would offer splendid opportunities for illustrating the rules for the operations with negative numbers, which are such a stumbling block to the average young student.

26. We now have sufficient idea of the mathematical principles involved, for a complete understanding of the working of the slide rule whose representation forms the main purpose of this paper.

27. This slide rule, in a somewhat ideal form in so far as it is made out for neither steel nor cast iron, but for an ideal metal of properties between these two, is illustrated in fig. 5. It will be seen to have two slides in its ***upper section*** and three in its ***lower section***, and it is in so far identical with the rules made for the Bethlehem Steel Company, while in the rules more recently made it has been found possible and convenient to construct it with only two slides in the lower section also.

28. It is shown arranged for a belt-driven lathe (No. 43 [1]) with five cone steps, which are designated respectively by the numbers 1, 2, 3, 4, 5, from the largest to the smallest on the machine. This lathe has a back gear only, and the back gear in use is designated by the letter *A*, the back gear out by the letter *B*. It also has two countershaft speeds, designated respectively by *S* and *F*, such that *S* stands for the slower, *F* for the faster of these speeds.

29. The SPEED COMBINATION 3–*A*–*S* thus designates — to choose an example — the belt on the middle cone step, the back gear in, and the slow speed of the countershaft; and similarly, the combination 1–*B*–*F* designates the belt on the largest cone step on the machine, the back gear out, and the fast speed of the countershaft; and so on.

30. The double, fixed scale in the middle of the rule (marked FEED) is equivalent to the *y* scale of the rule in fig. 4, and the scales nearest to this on the slides on each side of it (marked SPEED COMBINATION FOR POWER, and FOR SPEED, respectively) are equivalent to the *x* scales on the rule in fig. 4. The rest

[1] The main frame of the rule is used for a number of lathes, and is arranged to receive interchangeable specific scales for any lathe wanted, as may be seen in the illustration.

of the scales represent the various other variables that enter into the problem of determining the proper feed and speed combination to be used, fixed values being either directly given or assigned to these other variables, in any particular case under consideration.

31. The upper section of the rule embodies all the variables that enter into the question of available *cutting pressure* at the tool, while the lower section embodies all the variables that enter into the question of *cutting speed;* or, in other words, the upper section deals with the *pulling power* of the lathe, the lower section with the *cutting properties* of the tool; and our aim is primarily to utilize, in every case, both of these to the fullest extent possible.

32. The example for which the rule has been set in the illustration is: —

A ½ *inch* depth of cut to be taken with each of two tools on a material of class 14 for hardness, and of 20 *inches* diameter, and the tools to last 1 *hour and* 45 *minutes* under a good stream of water.

33. The steps taken in setting the rule were: —

1. The first scale in the upper or POWER section of the rule, from above, was first set so that 2 in the scale marked NUMBER OF TOOLS became coincident with ½ *inch* in the fixed scale marked DEPTH OF CUT FOR POWER.

2. The second slide in this section of the rule was so set that 20 *inches* in the scale marked DIAMETER OF WORK FOR POWER became coincident with 14 in the scale marked CLASS NUMBER FOR POWER.

3. The first slide from below, in the lower or SPEED section of the rule, was so set that the arrow marked WITH WATER became coincident with 1 *hour* 45 *minutes* in the fixed scale marked LIFE OF TOOL.

4. The arrow on the lower side of the second slide in this section of the rule was set to coincide with ½ *inch* in the scale marked DEPTH OF CUT FOR CUTTING SPEED.

5. The third and last slide in this section was so set that 20 *inches* in the scale marked DIAMETER OF WORK FOR CUTTING

SPEED became coincident with 14 in the scale marked CLASS NUMBER FOR CUTTING SPEED.

Let us now separately direct our attention to each of the two sections of the rule.

34. In the POWER section we find that all the speed combinations marked *B* (back gear out) lie entirely beyond the scale of feeds, which means that the estimated effective pull of the cone belt reduced down to the diameter of the work, does not represent enough available cutting pressure at each of the tools to enable a depth of cut of ½ inch to be taken with even the finest feed of the lathe. Turning, however, to the speed combinations marked *A* (back gear in), we find that with the least powerful of them (5–*A*–*F*) the *e* feed, which amounts to 5/128 inch = 0.039 inch, may be taken; while the *f* feed, which amounts to 1/20 inch = 0.05 inch, is a little too much for it, though it is within the power of the next combination (5–*A*–*S*), and so on until we finally find that the most powerful combination (1–*A*–*S*) is nearly capable of pulling the *i* feed, which amounts to 1/10 inch = 0.1 inch.

35. In the SPEED section of the rule we likewise find that all the *B* combinations lie beyond the scale of feeds, while we find that the combination 5–*A*–*F* (which corresponds to a spindle speed of 11.47 revolutions per minute), can be used in connection with the finest feed (*a*) only, if we are to live up to the requirements set for the life of the tool; while the next combination (4–*A*–*F*) will allow of the *e* feed being taken, the combination 3–*A*–*F* of the *f* feed, and so on until we finally find that the combination 3–*A*–*S* is but a little too fast for the coarsest (*o*) feed, and that both of the slowest combinations (1–*A*–*S* and 2–*A*–*S*) would permit of even coarser feeds being taken, so far as only the lasting qualities of the tools are concerned.

36. We thus see that there is a vast difference between what the POWER section of the rule gives as possible combinations of feeds and speeds for the utilization of the full pulling power of the lathe, and what the SPEED section of the rule gives for such combinations for the utilization of the tools up to the full limit set. However, by again running down the scale of feeds we find

that, in both sections of the rule, the *i* feed (1/10 inch = 0.1 inch), is but a trifle too coarse for the combination 1–*A*–*F*, while the *h* feed (5/64 inch = 0.078 inch) is somewhat too fine in connection with this speed combination 1–*A*–*F*, both for the full utilization of the pulling power of the belt on the one hand, and for the full utilization of the cutting efficiency of the tools on the other hand.

37. In this case, accordingly, the rule does not leave a shadow of doubt as to which speed combination should be used, while it leaves us to choose between two feeds, the finer of which does not allow us to work up to the full limit of either the belt or the tools, and the coarser of which will both overload the belt a trifle and ruin the tools a trifle sooner than we first intended to have them give out.

38. The final choice becomes a question of judgment on the part of the *Slide Rule and Instruction Card Man*, and will depend upon how sure he is of having assigned the correct CLASS NUMBER to the material or not; and this latter consideration opens up a number of questions in regard to the practical utilization of the rule, which for the lack of time cannot be taken up in the body of this paper, but which will be fully answered by the writer in any discussion on the subject that may arise.

39. Having decided upon the speed and feed to use, the Instruction Card Man now turns to the TIME slide rule illustrated in fig. 6, and by means of this determines the time it will take the tools to traverse the work to the extent wanted, and making a fair allowance for the additional time consumed in setting the tools and calipering the work, he puts this down on the instruction card as the time the operation should take.

40. For finishing work the pulling power cuts no figure, so that this resolves itself into a question of feed and speed only; and for the selection of the speed combination that on any particular lathe will give the nearest to a desired cutting speed, the SPEED slide rule[1] illustrated in fig. 7 is used.

41. It will readily be realized that a great deal of preliminary work has to be done before a lathe or other machine tool can be successfully put on a slide rule of the kind described above. The

[1] Described in *American Machinist* of November 20, 1902.

feeds and speeds and pulling power must be studied and tabulated for handy reference, and the driving belts must not be allowed to fall below a certain tension, and must, in every way, be kept in first class condition.

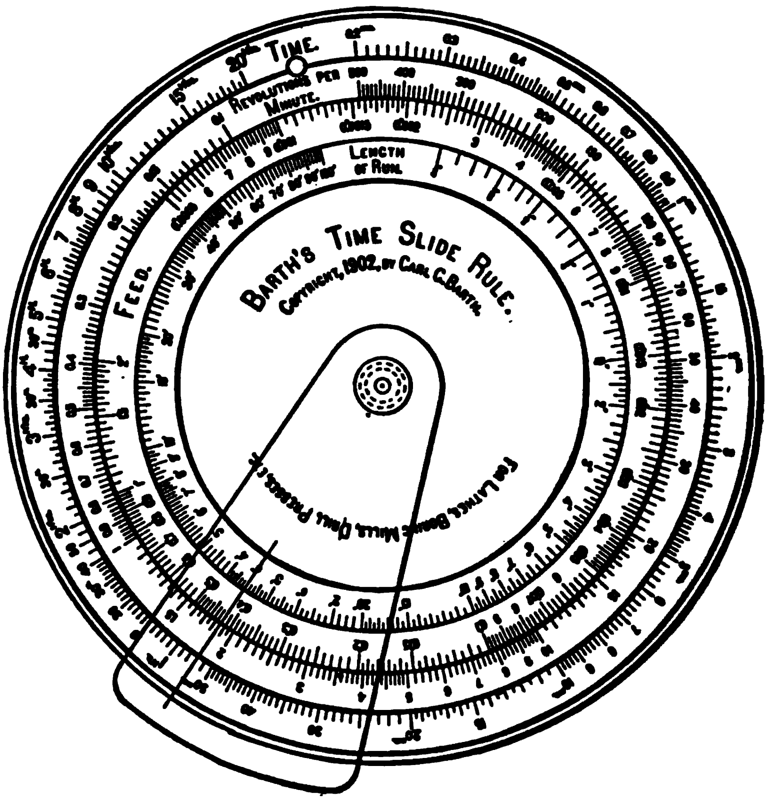


FIG. 6.

42. In some cases it also becomes necessary to limit the work to be done, not by the pull that the belt can be counted on to exert, but by the strength of the gears, and in order to quickly figure this matter over the writer also designed the GEAR slide rule [1] illustrated in fig. 8, which is an incorporation of the formulæ established several years ago by Mr. Wilfred Lewis.

[1] Described in *American Machinist* of July 31, 1902.

43. For the pulling power of a belt at different speeds, the writer has established new formulæ, which take account of the increasing sum of the tensions in the two sides of a belt with increasing effective pull, and which at the same time are based on

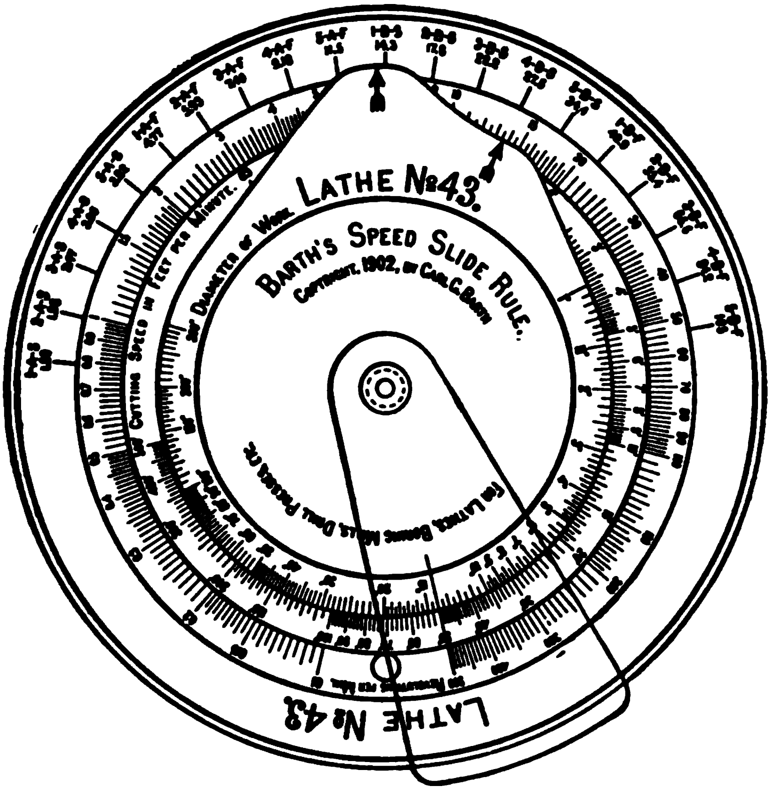


FIG. 7.

the tensions recommended by Mr. Taylor in his paper entitled "Notes on Belting," which was presented at the Meeting of the Society in December, 1893.[1]

44. These formulæ have also been incorporated on a slide rule, but as the writer hopes at some future time to prepare a separate paper on this subject, he will not go into this matter any further at the present time.

[1] See *Transactions of the American Society of Mechanical Engineers*, Vol. 15, p. 204. — ED.

45. Having thus given an outline of the use of the slide rule system of predetermining the feeds and speeds, etc., at which a machine tool ought to be run to do a piece of work in the shortest possible time, the writer, who has made this matter an almost exclusive study during the last four years, and who is at present

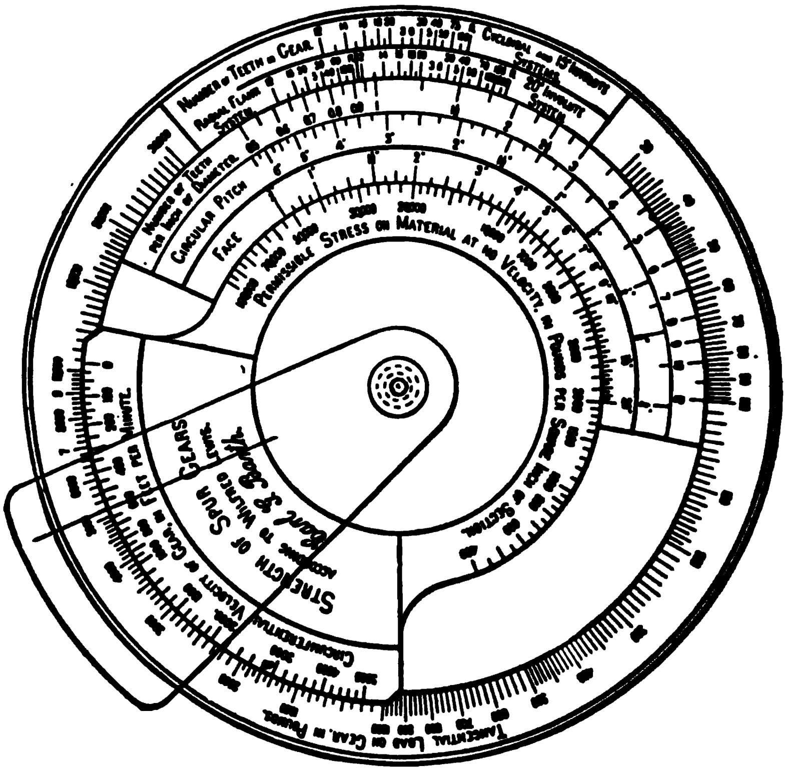


Fig. 8.

engaged in introducing the Instruction Card and Functional Foremanship System into two well-known Philadelphia machine shops, which do a great variety of work in both steel and cast iron, will merely add that, in view of the results he has already obtained, in connection with the results obtained at Bethlehem, the usual way of running a machine shop appears little less than absurd.

46. Thus already during the first three weeks of the application of the slide rules to two lathes, the one a 27 inch, the other a 24 inch, in the larger of these shops, the output of these was increased to such an extent that they quite unexpectedly ran out of work on two different occasions, the consequence being that the superintendent, who had previously worried a good deal about how to get the great amount of work on hand for these lathes out of the way, suddenly found himself confronted with a real difficulty in keeping them supplied with work. But while the truth of this statement may appear quite incredible to a great many persons, to the writer himself, familiar and impressed as he has become with the great intricacy involved in the problem of determining the most economical way of running a machine tool, the application of a rigid mathematical solution to this problem as against the leaving it to the so-called practical judgment and experience of the operator, cannot otherwise result than in the exposure of the perfect folly of the latter method.

A GRAPHICAL DAILY BALANCE IN MANUFACTURE

By H. L. Gantt

1. At the December meeting in 1901 the writer presented a paper entitled "A Bonus System of Rewarding Labor,"[1] in which was given an account of the results gotten under that system at the works of the Bethlehem Steel Company, and a description of the method employed.

The paper dealt particularly with the method of setting a task and with the reward for its accomplishment. It consisted briefly in setting as a task for a day's work the amount that a good man could reasonably be expected to accomplish, and paying the man a substantial amount in addition to his day's wages if the whole amount was done. If less than that amount was done he simply got his day's wages.

The result of this system, when the task was set in an intelligent manner and accompanied by a suitable compensation, was an efficiency of operation so far beyond that obtained by the ordinary day or piece work method that it attracted a great deal of attention.

This centering of the attention on the result had, however, a serious disadvantage, for it withdrew the attention from the most important parts of the paper — namely, that describing the method of setting the task, and that referring to the method of operating the system by which an exact record was kept.

The method of setting the task is substantially that developed by Mr. Fred W. Taylor for setting piece rates, and was described at some length. His paper before the present meeting further elucidates that part.[2]

[1] Incorporated in substance in H. L. Gantt's "Work, Wages and Profits."—Ed.

[2] Referring to F. W. Taylor's "Shop Management." — Ed.

The routine operation of the system, which involves keeping an exact daily record of the work done, was not, however, so clearly explained, and it is to that subject that this paper is devoted.

2. *Man's Record.* — In order to operate such a system we must not only have an exact record of what each workman does every day in order to find out whether he has earned his bonus or not, but must have beforehand an exact knowledge of the work to be done and how it is to be done. This amounts to keeping two sets of balances: one, of what each workman should do and did do; the other, of the amount of work to be done and that is done. The former, or man's record, is concerned with the payment of the bonus, and consists in an exact comparison of what should be done as determined by our investigations, and what has been done as shown by the daily reports.

3. *Daily Balance of Work.* — The latter is a balance of work on each order, and should show at a glance each day just what has been done and what remains to be done, in order to enable us to lay out the work for the next day in the most economical manner. The importance of such a balance has been long recognized, but the difficulty of getting it is such that it has seldom been attempted. Many concerns get a weekly or monthly balance; but in both of these cases the information is usually obtained too late to prevent delays in work. Again the value of a balance is dependent largely upon its availability; in other words, upon the ease with which the desired information can be obtained from it. With this idea in mind the writer devised a combined schedule for work and a balance sheet that is largely graphical in its nature. On it dates are represented by positions, and when work is not done on consecutive days, there are no entries in consecutive positions. This practice enables the foreman or superintendent to see at a glance what work is going along properly. Such schedules can be made out for all classes of work, and a description of one or two will amply illustrate the principle.

4. *A Foundry Balance.* — Fig. 289 represents such a balance sheet and schedule for a foundry. At the heads of the various

vertical columns are the names of the pieces to be cast, under each is its pattern number; then, in order, when the pattern is due at the foundry, when it is received, the number wanted per day, and the total number wanted. Below, each column is divided into two columns headed *daily* and *total*. These are crossed by horizontal lines representing consecutive working days, on each of which is entered in the proper column the number of pieces made that day and the total number made to that date. Each column is crossed by two heavy horizontal lines, the upper one opposite the date at which the work should be begun, and the lower one opposite the date at which the work should be completed. These lines are usually red, and have been very appropriately named *danger lines*. The position of the entries with reference to these danger lines and the amounts of those entries show to what extent the schedule is being lived up to. If the schedule is being well followed the entries are always in the neighborhood of the red lines, or above them.

Fig. 289 represents a portion of an actual order showing how it was filled in the foundry of the Schenectady works. If there is no graphical check on the operations of the foundry, the work that is wanted during a certain week may be spread over three or four.

It is an extremely difficult matter for a foreman to get the work done exactly in the order it is wanted. For instance, if we are building two locomotives per day, each requiring four driving boxes, it seems an extremely difficult thing for him to get every day, without fail, at least eight driving boxes. There is a constant tendency when he is rushed with work to drop to seven or six with a corresponding decrease in output of locomotives. This tendency to give about what is wanted, rather than exactly what is wanted, is the most common obstacle to getting the full output of a plant.

5. *A Daily Balance as a Permanent Record.* — This balance sheet shows not only how much work was done each day, but is a permanent record of exactly how the order was filled, which can be compared with the record of the previous and subsequent orders. This is best illustrated by a study of fig. 289, which

results obtained. In large plants run without such a system of balances it is frequently impossible to tell just what is holding back the output, and then the value of such a balance is out of all proportion to the cost of obtaining it. By using the graphical form its value is very much increased, for the general appearance of the sheet is sufficient to tell how closely the schedule is being lived up to; in other words, whether the plant is being run efficiently or not. Moreover, such a balance is a history of the way the work went through the shop and is readily comparable with similar work done previously or subsequently, thus enabling us to form a definite idea as to whether the plant is being run more or less efficiently. The balance of work sheet then gives us a daily analysis of how the work is progressing, and in its graphical form is so easily read that both foreman and superintendents find it of great value. The man's record shows the efficiency of each man, and the two taken together give us the knowledge, in the clearest way, of what should be done to increase our output.

8. *Value of Balance not Dependent upon Method of Compensation.* — It is not the intention of this paper to discuss the making of schedules for doing work, or instruction cards for the workmen to follow, or indeed the subject of compensation for work done, for the keeping of a daily balance of work done and a record of the men doing it are invaluable, no matter what the method of compensation. In fact, the writer has found the *man's record* when work was done by the day to be of the highest value, for when the men realize that not only their chance for increase of wages, but that of holding their positions depends upon the amount and quality of their work, they become very much more efficient. Add to this the fact that efficient men paid in proportion to their efficiency are invariably better satisfied than less efficient, cheaper men, and we have an added reason for keeping the man's record. Again a workman easily forgets how many days he has been absent, and how much poor work he has done, and an occasional glance at his record often does him a great deal of good. The writer first kept such a record in the foundry of the Midvale Steel Company thirteen years ago, and found it so valuable that he has always done it since when possible. Such record sheets are so easily gotten up

and of so many kinds that the writer has not considered it necessary to illustrate them.

9. *The Graphical Balance and the Foreman.* — Next to the superintendent the most overworked people in the ordinary manufacturing plant are the foremen. Their duties may be summed up as follows, in the order of their importance: to get their work out on time; to get it out economically; to improve their methods. Add to their primary duties a multitude of others depending upon them, and but little time is left for thought, or investigation, on which depends improvement. When they are rushed, therefore, improvement is naturally the first thing to suffer. Further pushing causes economy to be sacrificed, for the work must get out, and the foreman has not time to go over and over his orders to see just what is the most economical arrangement of his work. Here is where the graphical schedule comes to his assistance, for he can see at a glance just what is behind or what should be done next. There has been but little difficulty in getting foremen to recognize the value of such a balance, and I have yet to learn of one, who, having gotten such a sheet in full operation, was willing to give it up.

10. *Cost of Keeping Balances.* — The question is frequently asked as to the cost of keeping these records and balances. In reply I have to say that if such cost were ten times what it is, it would cut no figure.

In day work we buy a man's time, and he frequently gives but little else. Our storekeeper checks exactly the materials we buy, but nobody knows exactly what the day workman has done in his ten hours; although we know labor to be the most difficult commodity we have to buy, we give it the least systematic study, and my effort to get an exact record of what we get for our money is the first step toward purchasing it in an intelligent manner. With regard to the balance of work, I can only say that it is hard to estimate the cost of lack of harmony in a plant, and the increase in efficiency produced by getting materials in their proper order rather than according to the judgment of the various foremen is greater than is usually realized.

The fact that, as far as the writer's experience goes, the foremen are not only willing to use these graphical sheets, but are glad to do so in order to make their work harmonize with that of other departments, is the strongest proof of the value of the graphical over the other forms of balance.

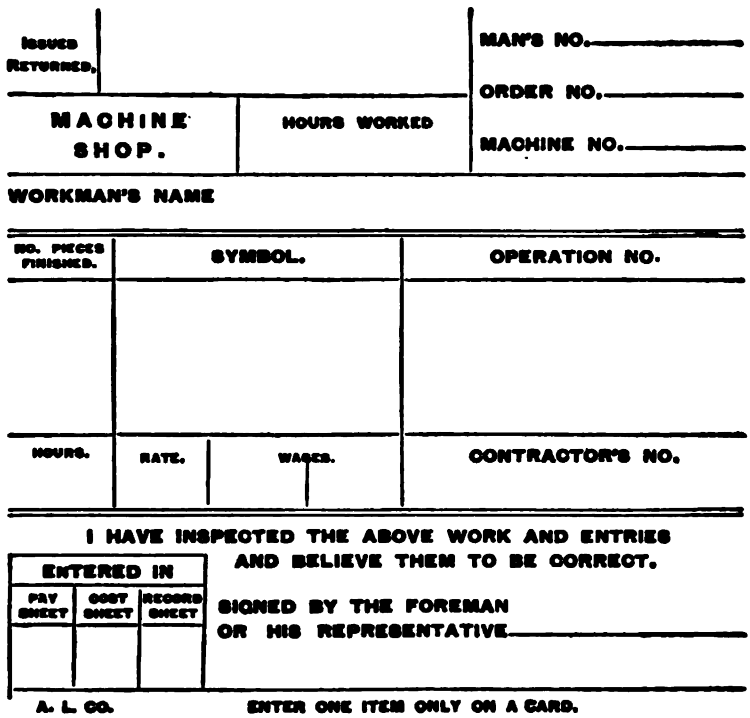
The value of a balance of some sort is too well understood to need discussion, and the only reason that it has not been adopted is often the fancied cost of getting it. As a matter of fact, all I have suggested can usually be gotten by the ordinary time and cost keeping force with but little help, and frequently without any. It is so closely allied to the time and cost keeping that when all are done together by the best modern method, the reduction of labor in getting the time and cost often more than offsets the increase due to keeping the men's records and the balance of work. The method referred to is the *time and production card* system, of which the following is a description. There are conditions under which the system to be described here may be modified; in fact, it is not always found possible to introduce it exactly as described, which, however, is the ideal method of operating it and should be approximated as nearly as possible. It was first introduced substantially in this form by Mr. Fred W. Taylor at the works of the Bethlehem Steel Company.

11. *Time and Production Card System.* — In its best development, a card is assigned the day previous to every man who is expected in at 7 A.M. the next day. Each of these cards is stamped with a rubber stamp 7 A.M. and the date. These cards are placed in a rack, which has a properly numbered space for each man, who takes from it his own card and no other.

Any men coming in after 7 A.M. are not allowed access to the rack, but must get their cards from the office, where the cards are marked properly by a time stamp with the exact time each man comes in.

Without any delay each man goes directly to the work that has been assigned to him, and while his machine is running, fills in on the card his name, his number, the order number, the machine number and the kind of work he is doing. At the end

of the day he enters on his card the number of pieces that have been correctly finished, and the card is signed by the foreman or inspector, certifying that all of the entries are correct. If there have been errors in the work the foreman or inspector does not



ISSUED
RETURNED,

MAN'S NO.

ORDER NO.

MACHINE SHOP.

HOURS WORKED

MACHINE NO.

WORKMAN'S NAME

NO. PIECES FINISHED.	SYMBOL.	OPERATION NO.

HOURS.	RATE.	WAGES.	CONTRACTOR'S NO.

I HAVE INSPECTED THE ABOVE WORK AND ENTRIES AND BELIEVE THEM TO BE CORRECT.

ENTERED IN		
PAY SHEET	COST SHEET	RECORD SHEET

SIGNED BY THE FOREMAN
OR HIS REPRESENTATIVE

A. L. CO. ENTER ONE ITEM ONLY ON A CARD.

Fig. 292.

sign the time card, but makes out a supplementary card stating the exact nature of the errors, etc., and pins this card to the time card.

Fig. 292 represents a suitable form of *day work* card for use in some of the machine shops of the American Locomotive Company in connection with this system.

At the end of the day, or at noon the men are allowed access to the card racks as soon as the whistle has blown, and each man deposits his card in the proper pocket, an observer noting that a man deposits one card only.

Men coming in after noon get their cards in the same manner as in the morning; the cards being previously stamped with the hour work begins, and placed in the rack. Men who do not go out at noon do not need to change their cards.

When the men have gone out at the end of the day or at noon, the cards in the rack are stamped by means of a rubber stamp with the time the work ends.

The preferable form of card is a square one on paper stout enough to be shuffled. In the upper right-hand corner of the card should be placed the man's number, the order number and the machine number.

As there is room for one order number and one machine number only on one card, the workman must give in his card at the office and get a new one whenever he goes either on a new order or another machine.

12. *Time and Man's Record.* — In order to get a record of the man's time and work for the day, all the cards bearing his number must be gotten together. If these do not give a total of the full number of working hours, the first card of the day must show that he was late, or there must be a pass stating what time he went out. These passes should be of the same size as the cards, and be put in with the time cards and sorted out by the man's number, so that when the clerk begins to enter the time and record he will have all the information at hand. The men's record may serve as a pay sheet, thus involving only one set of entries. When the time is entered up, the clerk doing it enters his initial in the lower left-hand corner in the space marked " pay-sheet."

13. *Cost.* — To get the cost on an order the cards are then sorted by " order number," and when the clerk begins to enter up the time or wages against any order, he should have before him all the cards representing work on that order. He is thus enabled to make the final entry directly from the cards, thus doing the work with a minimum of clerical labor. The clerk enters his initial in the space designated for such entry on " cost sheet."

14. *Progress or Production.* — To get a record of the work on any order, the cards which have been sorted by order number are further sorted by name of part and operation. We thus get together the cards showing on an order the number of pieces on which a certain operation has been finished that day. These are added up and entered directly on the *Production or Progress* sheet. By this method we can keep an intelligible record of all the work done with a minimum of clerical labor.

15. *Difficulty of Getting a Daily Balance.* — It is not necessary for the purpose I have in mind to dwell further on the details, my object being only to show that the difficulty of getting this daily record of our men and a balance of work done is not so great as to be prohibitory. In other words, *it is an entirely feasible thing to know exactly all that has been done in a large plant one day before noon of the next, and to get a complete balance of work in order to lay out* THAT AFTERNOON *in a logical manner the work for the next day.*

16. *Value of such a Balance.* — The value of such a balance consists in the fact that it makes clear details that no observer, however keen he may be, can see by inspection. It shows us what work is behind and how much, and enables us to trace to its source the cause of any delay. The superintendent sees at a glance what he never could find out by observation or by asking questions. It shows him how efficiently a plant is being run and where the defects in operation are. In connection with the man's record, it is the most complete analysis we can make of the working of a plant, and the one that will help us most quickly to bring into their proper channels things that have been going haphazard. Such an analysis is far more important than an improved tool steel or a new set of piece rates. It should be established before the introduction of either of these in order that we may have some means of measuring the gain made by their introduction, and it should remain after they are introduced to show that a forward step once taken is never retraced.

17. *Accounting and Operating.* — In conclusion the writer wishes to say that it is his opinion that we can do nothing in a

manufacturing plant that will go so far toward increasing the output or the economy of operation as obtaining this exact knowledge of what is being done. The cost of getting it is almost nothing, and the methods of operation need not be disturbed in the least until an accumulation of knowledge points out the best course to pursue.

By the adoption of the methods outlined the accounting department ceases to be simply a critic of the manufacturing, and becomes an active assistant to every foreman and to the superintendent. In other words, the accounts cease to be simply records of production, and become potent factors in helping the producing departments.

18. *The Bonus System a Form of Profit Sharing.* — Having established these combined order, schedule, and production sheets, the next step is to pay *a bonus* to the head of each shop based on the extent to which he adheres to the schedule as laid out. These sheets thus do for the foreman what the *Instruction Card* does for the individual, and the final result of the system is harmonious working and a high degree of efficiency, a portion of the profits of which goes directly to the individual in proportion as his efforts tend to maintain that efficiency. Carried out to its logical end, therefore, the *Bonus System* as described in my previous paper becomes practically one of *profit sharing*, in which each man gets his portion of the profits as soon as he earns it.

In this paper I have confined myself as nearly as possible to general principles, using specific cases simply as illustrations. These principles are capable of further development and may be worked out in detail to suit the needs of many forms of manufacture.

Mr. McGeorge. — Mr. Gantt in his paper spoke of not requiring any further clerical help. I would like to inquire how he manages that? Does he appoint special corps of clerks for this purpose, or has each foreman a clerk? Then again, who settles when these various parts shall be assembled? In other words, who fills out the sheets to begin with? Then he also spoke of a danger signal — a red line. I would like to ask who puts that red line on?

Mr. Gantt. — In answer to Mr. McGeorge's question I may say that the whole schedule, red lines and all, should originate in a planning department such as is advocated by Mr. Taylor, but as few plants have such a department, it is usually impossible at first to do this work as it should be done, and the schedules have to be made out by those most available for the purpose.

Comparing the manufacture of locomotives with that of any other large machines, a very casual investigation will be sufficient to show that the art of building locomotives is by far the most fully developed, and that the harmony between the different portions of a locomotive plant is much more perfect than that in any other plant of the same size building large machinery. This is so because locomotives are always built according to a schedule, which is the evolution of more than half a century's work in the same line.

What time and evolution have done for the building of the locomotive, Mr. Taylor does for the building of machinery in general by means of his planning department. What I have done is to put in a graphical form not only the schedule for building the locomotive, but to show graphically how that schedule is carried out. At the locomotive works we made no attempt to modify or criticize the existing schedule, but simply recorded how the schedule was lived up to.

These combined schedules and records become a history of how the work went through the shop and will ultimately supply the information needed in modifying the schedules so as to get still greater harmony between the different departments and greater economy of manufacture.

Where pretty complete schedules exist, as in most locomotive plants, anybody in authority can see that they are made out in a graphical form and lived up to. Three examples given below will show how this work can be started under these conditions. Even where there are no well defined schedules there is always a certain amount of knowledge that takes their place, and the collection of this knowledge and the putting of it in a graphical form can always be done. Such schedules are necessarily imperfect at first, but are far better than nothing, and, if the records are properly kept, may be rapidly improved, especially if a planning or production department is organized to develop them as rapidly as possible.

The three examples referred to above are as follows:

At the Manchester Works of the American Locomotive Company, Mr. Ayres, the superintendent, gave his personal attention to having them started in the foundry.

At the Schenectady Works Mr. Peck, foreman of number one machine shop, personally looked after their introduction in his shop.

At the Brooks Works Mr. Reid, the assistant superintendent started them in the foundry. He is not here, so I shall tell you of his results. He personally put the red lines on to start with, and had the sheets sent to his office every morning at ten o'clock with the previous day's work written up to see how the schedule was being lived up to. They were sent back with his written comments to the foreman in time for him to arrange his work for the next day. The result of this was a prompt improvement in the output of the foundry. The best illustration I can give you of his success is to show you these order sheets for thirty-five locomotives filled by that foundry about eight months after the system was started. (Here were shown several actual schedule sheets of this order with the red lines and entries exactly as kept in the foundry office as reproduced in figs. 289, 290 and 291.)

If you can see the red lines and the entries, you can see how the schedule was lived up to. Suffice it to say that out of a total of over nine thousand castings, none were more than five days behind schedule time, and only two, which were replacements, more than four days. This is a record that any foundry might be proud of. Don't imagine, however, that the system alone did it. The system simply supplied the means by which it could be done, and the man trained to use the system and to know its value got the results. The fact that a man capable of using the system must be found or developed is one reason why it takes so long to get it properly started.

There is one other thing which I did not quite get to in presenting my paper — the difficulty of getting this daily balance. "It is not necessary for the purpose I have in mind to dwell further on the details, my object being only to show that the difficulty of getting this daily record of our men and the balance of work done is not so great as to be prohibitory." *If it cost fifty times what it does, it would pay.* To know exactly all that was done in a large plant one day before noon of the next, and to get a complete balance of work in order to lay out that afternoon in a logical manner the work for the next day, enables us to *manage a large plant as intelligently as a small one.*

THE TOOL ROOM UNDER SCIENTIFIC MANAGEMENT

A DESCRIPTION OF WHAT IS REQUIRED OF A TOOL ROOM IN A MODERNIZED SHOP — A TOOL CLASSIFICATION, NOTES ON STORAGE, MAINTENANCE, CHECKING AND INVENTORY SYSTEMS DRAWN FROM PRACTICE

BY ROBERT THURSTON KENT

EDITOR OF INDUSTRIAL ENGINEERING

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ONE of the fundamental conditions required by scientific management is that the skilled worker be provided with the best appliances and tools required for his work. In the machine shop these include not only the cutting tools and jigs, in addition to the machine tools, but also every fixture required to hold the work in the machine and to measure it while in process and on its completion. These appliances comprise among others clamps, bolts, dogs, blocks, gages, etc. Scientific management also requires that tools and fixtures such as enumerated above be always kept in first class condition. The reason for this is that the time of performing an operation, which is determined beforehand, is based on the time required only with appliances in the best working order. As an illustration we may cite the case of a dog used to drive work held on centers in a lathe. It often happens that the thread of the clamping screw in the dog becomes damaged and, therefore, requires the application of a wrench to run it down to the work. The time predetermined for this operation is based on the machinist being able to run the screw down to the work quickly with his fingers and only applying a wrench to give the last one-eighth of a turn to tighten the screw on the work. Should it be necessary for the machinist to run the screw all the way down with a wrench, obviously he will exceed the length of time allowed for placing the dog in position and thus be in danger of losing his bonus for that particular piece of work.

In order to insure that all these various appliances be maintained in good order it is essential that they be kept in the tool room and in charge of a person competent to inspect and repair them or to issue instructions for their repair should it be necessary to do this work outside in the shop. Under the usual system of tool rooms, only the highest priced and finer tools are found in the tool room. Thus we find drills, taps, reamers, gages, jigs, and such fixtures in the tool room, while lathe tools are kept at each machine, milling cutters at the various milling machines, a complete set of planer tools at each planer, while blocks, bolts and clamps of various kinds are obtained wherever the machinist can find them. They are *supposed* to be in the shop, but no one in particular is responsible for their being there, for seeing that they are supplied in sufficient quantity or in the proper variety of sizes to take care of the different kinds of work done in the shop. The consequence is that the machinist given a certain piece of work to do often wastes much time hunting for the correct sizes of blocks, bolts and clamps, and when he finds these loses more time because they are not in the best of condition and require the application of a wrench to nuts and screws which should run down with the fingers, or in matching up two or three sizes of blocks to form blocking of the requisite height. After having the work mounted in the machine he will use a cutting tool more or less well adapted to the work in hand and often ground to suit his own peculiar ideas.

Now there is a certain shape of tool best adapted to each individual kind of work and this tool should be ground at certain definite angles which have been found the best by a long series of experiments. Records of these shapes and angles are available for any one who cares to make use of them.[1] It is obvious that if all tools are to be ground to these correct angles, that the grinding of them should be taken from the men in the shops and placed in the hands of the man in the tool room. He should be provided

[1] These shapes and angles are given in the *Art of Cutting Metals*, by Frederick W. Taylor.

with a universal tool grinding machine which will grind the tools to predetermined angles and shapes, and grind every tool to the same shape at one setting of the machine.

It is evident, therefore, that a tool room adapted for the needs of scientific management is a very different sort of a place from the ordinary tool room. We are enabled to present here, through the courtesy of the Tabor Manufacturing Company, Philadelphia, illustrations of a tool room planned and constructed in accordance with the principles of scientific management. Certain fundamentals must be constantly kept in mind when laying out a tool room. It should provide storage places for the tools which are economical of space, which permit of easy rearrangement and extension as the tool room grows, and which are so arranged that the distribution of light is the best possible. A certain definite and fixed place must be provided for every tool that is stored in the tool room, and this place must be easily ascertained even by a newcomer into the tool room, who is unfamiliar with its arrangement. A checking system must be provided which will account for and locate every tool for which the tool room is responsible, whether the tool has been issued to a workman in the shop, sent to the blacksmith for reforging, or to the grinding room for grinding. A stock of tools of ample quantity for all the shop requirements must constantly be kept on hand, and these must be maintained in the best condition at all times, means for such maintenance being provided. These various points will be taken up and discussed in order.

Classification

Every tool, jig, fixture, block, clamp, etc., should be classified according to the use to which it is to be put. The classification is just as important, perhaps more so, as the provision of the standard storage racks, described later. The classification is what determines the location of the tools in the tool room and also what enables the attendant, however unfamiliar he may be with its arrangement, to find a given tool almost instantly. In view of its importance we will discuss it in some detail.

FIG. 1. -- Rack for lathe and planer tools.

The general scheme of classification recommended is that devised by Mr. F. W. Taylor and shown in Table I. Every tool used in a machine shop falls within one or another of the general classes there given.

TABLE I — CLASSIFICATION OF TOOLS

CLASS

A — Miscellaneous Tools, not elsewhere classified.

B — Bending Tools. — All tools for producing changes in shape by bending, folding, spinning, etc.

C — Clamps and Holding Devices of all kinds, including bolts and screws.

D — Drilling and Boring Tools. — Tools that remove metal from the interior, such as drills, boring bars, cutters and all appliances relating to them, and lathe boring tools.

E — Edge Tools. — Edge tools for working wood, and tools for working plastic materials, such as clay, molding sand, putty, etc.

F — Heating Tools. — All kind of tools used for heating, lighting, melting, molding, oil tempering, annealing, drying, cooking, etc.

H — Hammers and all Tools that work by striking or being struck, such as sledges, tups, etc., chisels, sets, flatters, etc.

L — Transportation Tools. — All tools used in moving materials from one place to another, such as buckets, boxes, etc., trucks, shovels, wheelbarrows, bogies, brooms, riggers' tools, slings, chains, etc.

M — Measuring Tools. — All instruments of precision, weights, measures, gages, etc., electrical instruments, etc.

P — Paring Tools. — All tools that remove metal from the surface by cutting, except slotter and milling tools. (See class D for lathe boring tools.)

R — Milling Tools. — All tools for milling or sawing metal.

S — Slicing Tools. — All parting tools and slotter tools.

T — Templates and all Instruments for duplicating work, including jigs and fixtures.

U — Abrading Tools. — All tools for rubbing, scraping, filing, grinding, shearing, punching, breaking, etc.

W — Wrenches and all Tools used for causing rotation.

X — Painting Tools. — All tools used for covering a surface with an adhesive foreign material, and any for removing same.

These general classes can be divided into subclasses and the subclasses can be further subdivided and re-subdivided down to the individual tool, as the requirements of the shop dictate. A single instance will suffice for illustration. Lathe tools are evidently tools for removing metal from the surface of a piece by cutting. From Table I such a tool is in class P. The tool might have either a square or a round nose, and if the latter it might be of several different shapes. Assume it is blunt. Furthermore,

Fig. 2. — Rack with boxes, drawers and trays for boring and drilling tools.

the nose might be in a straight line with the shank, or it might be offset to the right or left. The cutting edge also might be either on the right or left. Assume that the tool is straight and that the cutting edge is to the left. The first letter of the tool symbol is evidently P. The second letter denotes the shape of the tool, and being a round nose the symbol from the Taylor classification will be R. The third letter will designate the shape of the nose and the symbol for a blunt nose happens to be B. To show that the blunt, round-nose, lathe tool is straight with the cutting edge to the left, the letter C from the Taylor classification is added. The complete symbol for the tool which clearly identifies it, excepting with regard to its size, is therefore PRBC. The size of the tool, meaning the width of the bar stock from which it is forged, is then prefixed to the symbol in the shape of a numeral, and the entire description of the tool is comprised in five characters, *viz.*, 2PRBC for a 2 in. tool.

The symbol for each tool is stamped on it in large, legible figures, and the tools are stored in racks, trays, boxes, drawers, etc., labeled with the corresponding symbol. The tools are also called for by the men by symbol, the planning department issuing its instructions to them in symbolical form as far as possible.

In connection with the classification of the tools, a classification book or sheet should be prepared, which serves two purposes. It locates a tool whose name and size are given but whose symbol is unknown, and it indicates the symbol for a new tool which has not as yet been classified. The classification book is a loose-leaf affair, or a series of blue-print sheets bound together in such fashion as to permit the insertion of an additional sheet at any point. The first sheet of the book carries the general classification shown in Table I. Reference to this sheet will indicate at once under which class a given tool will be found. Probably the system of locating a tool by means of the classification book can be best understood if we consider an actual case — the tool 2PRBC mentioned above, for instance. Assume that we are required to symbolize this tool, which is described as a 2 in.,

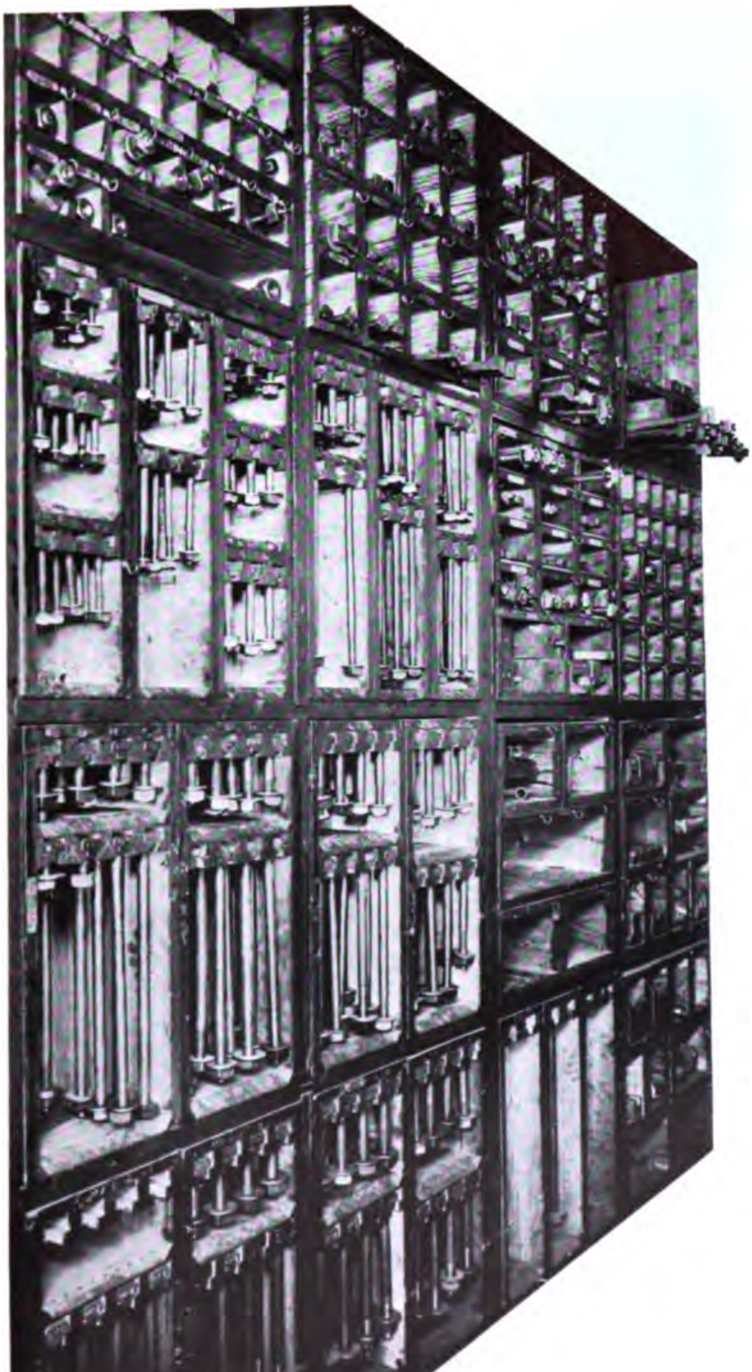

FIG. 4. — Rack showing adaptation of standard boxes for stocking holding-down bolts, etc.

FIG. 5. – Rack with compartments for jigs and templates.

Tool Cabinets and Racks

The illustrations, figs. 1–5, show a form of main rack, with various possible subdivisions by means of standard size boxes, trays and drawers for the storage of tools. The racks, figs. 1–5, are built on the unit system and by means of the standard boxes listed in Table II, and, by means of standard trays, present an almost unlimited number of combinations adapted to the needs of any character of establishment. Furthermore, they are sufficiently elastic to permit of any desired rearrangement and extension to provide for the growth of the shop.

The racks are built of sound lumber, planed on both sides, the various parts being mortised into one another. They should be heavily built to withstand the strain due to the weight of the large quantity of heavy tools carried by them. The compartments of the racks are made 24⅝ in. square, inside measurements, and they are 17 in. deep. These main compartments are clearly shown in all the illustrations, and fig. 3 shows clearly the various types of boxes, trays, drawers, etc., all adapted to one rack. For standard sizes of boxes, see Table II.

TABLE II — Standard Boxes for Subdividing Tool Racks

(All dimensions in inches, and are *outside* dimensions)

Box No.	Width	Height	Depth	Box No.	Width	Height	Depth
1	24	24	17	9	12	4	17
2	24	12	17	10	8	8	17
3	24	8	17	11	8	6	17
4	24	6	17	12	8	4	17
5	24	4	17	13	6	6	17
6	12	12	17	14	6	4	17
7	12	8	17	15	4	4	17
8	12	6	17				

The trays shown in fig. 1 are respectively 24 × 4 in., 24 × 6 in., and 4 × 4 in. Each tray is complete in itself and is labeled with a brass plate giving the symbol and size of the tool contained in it. But one size and shape of tool should be contained in a single tray, smaller trays being used for smaller quantities of tools. The lower front edge of each tray is beveled, and on it are placed pegs for the workman's checks which act as receipts when the tools are issued. The pegs have large heads to prevent the checks from being easily knocked off. These trays are best adapted to accommodate tools of class P.

Fig. 2 shows a rack, subdivided by boxes, trays and drawers, to accommodate boring and drilling tools, class D. The lathe boring tools are stored on trays like the class P tools in fig. 1, while the larger drills are stored in boxes and the smaller ones kept in drawers, each compartment holding two rows of drawers, which are subdivided into small compartments for the drills and which have places on the interior for the workmen's checks. Fig. 3 is a rack subdivided to take care of tools of various classes, and drawers for stocking milling cutters, these latter drawers being of the full width of the compartment and mounted on rollers. Each box and each drawer carries the customary brass label with the symbol of the contained tools thereon, and pegs or hooks for the checks which show the location of issued tools.

Fig. 4 shows a unique adaptation of the standard boxes and also illustrates in a measure the difference between a tool room under scientific management and the ordinary tool room. Holding-down bolts are usually kept at the machines in the shop, and are moved from one machine to another as they are needed. Frequently much time is lost by the machinist in hunting for bolts and frequently he cannot find bolts of exactly the required length. It is then necessary for him to find washers and packing pieces to fill up the extra length between the surface of his strap and the bottom of the thread on the bolt, this consuming more time. Scientific management regards the bolts needed to hold a piece of work in the machine as much a necessary part of the tools required as it does the lathe or planer tool which actually removes the metal. Therefore these should be cared for in the tool room and kept in just as good order as the other tools, and issued with them. Each bolt is complete with its nut and washer; and each bolt is inspected when it is returned to the tool room to see that the thread is in good condition so that the nut can be run down by hand, and that the nut is square so that the wrench will not slip on it. Defects of this character are repaired before the bolt is issued again. Should the requirement of a job call for say a

6 in. bolt and these happened all to have been issued, the next longest size in stock, say 6½ in., would be given out with a washer ½ in. thick, so that the workman would not have to waste time in finding washers, or in running the nut down the necessary distance. The bolts are suspended from T-slots at the top of the box, the symbol label being placed over the T-slot and the peg for the check directly underneath. Fig. 5 shows how the com-

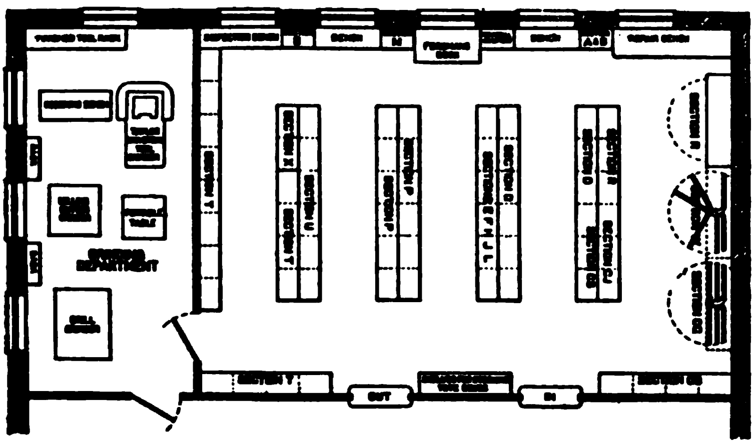

FIG. 7. — Approved plan of tool room for a shop having, say, 100 machinists.

partments can be subdivided for the storage of jigs and templates. The locations of the symbol labels and of the hook and pegs for checks are clearly shown.

. . . a large number of flat tools can be stored in a small space by means of swinging-door racks. Six of these doors are swung on one spindle, folding up against one another, as shown in the plan, fig. 7, at CC and W. The tools are carried on substantial hooks, and below each is the symbol label and a hook for the check.

The above illustrations show the extreme flexibility of the system of storage. It is evident that the system can be adapted to any type of manufacturing establishment according to its needs. In adapting it, however, stress must be laid on the importance of first classifying the tools and distinctly labeling each and every division in the storage racks with the symbol of the tools it contains, if the full benefits of the system are to be obtained.

CHECKING AND INVENTORY SYSTEM

The tools are issued to the workman only on the presentation of checks bearing his number and which act as a receipt for the tool. The man gives his check, which is hung on the peg or hook provided for that particular tool, or is placed in the drawer or compartment, before the tool is removed therefrom. This determines the exact location of the tool in the shop. On returning the tool, the man gives his number, which must correspond

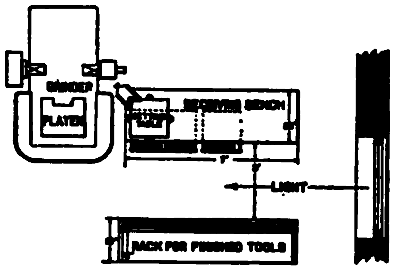

FIG. 8. — Recommended Arrangement of Tool Grinder.

with that of the check on the hook or in the drawer. If it does not, the check is withheld and an investigation is made. This eliminates the stealing of tools by one workman from another, to receive credit for them on their return to the tool room. Whenever a check is removed from its peg, the tool it represents must be replaced, or another tool room check, showing that the tool has been sent to the grinding department, the forge shop, or to some other department, must be hung in its place. When the tool comes back from such department, it is replaced and the tool room check is taken up. Thus every tool must be accounted for, either by the tool itself, a workman's check, or a tool room check.

The check system is somewhat simplified by the issuance of denominational checks, that is, checks which bear on the reverse side a numeral, as 2, 3, 5, etc. These are used when a quantity of tools of the same size and symbol are issued to one workman. Take, for instance, bolts. If four bolts of a size are withdrawn, the workman will present a check, bearing on one side his number and on the other the numeral 4. showing that he has taken four bolts from the particular section where the check is hung. These checks are of a different size and shape from those usually issued, to insure that attention will be directed to the numeral which shows the number of pieces that must be returned.

Inasmuch as every tool can be accounted for, by either checks or tools, the keeping of inventory is rendered a rather simple matter. A perpetual inventory is kept of all tools in the tool room, showing the number and value of each kind of tool in stock. Damaged tools or defective ones are either replaced or written off the inventory. Obsolete tools are written off, while additions are entered in the inventory. The perpetual inventory is indexed according to the classification. It is checked by referring to the classification to find the symbol, and then examining the compartment bearing this symbol. The sum of the number of tools in the tool room and the number of checks in the compartment should equal the number of tools called for by the inventory. Constant checking of this character is carried on from day to day to insure against loss through misplacement or other cause. With this system a detailed examination of the tool room for inventory purposes is unnecessary.

Issuing Tools to the Shop

Under the system of management in use at the Tabor Mfg. Co., which is regarded as one of the best examples of a scientifically managed shop in existence, a tool list is issued to the tool room by the planning department for every job assigned to the shop, so that the tool room may have the tools in readiness for the job in advance of the time they are needed. The tool list has printed on it in permanent form a list of the more commonly used tools, such as paring tools, lathe dogs, arbors, bolts, etc., with blank spaces in which can be written tools not printed in. A column is provided for the number required and another for the symbol. These columns are filled in by the planning department, the job number is added together with the workman's name or number and the list sent to the tool room. The tools are gathered together and placed in a tool box and are ready for the tool messenger when he calls for them, thus eliminating all waste of time while waiting for tools. The workmen do not go to the tool room, but are waited upon by messengers.

Tool Room Arrangement

Fig. 7 is an approved plan of a tool room for a shop employing, say, 100 machinists. It can be enlarged by adding additional racks so that it will accommodate the tools for three times that number, without disturbing to any extent the arrangement shown. The floor space required by the plan shown is 50 × 25 ft., including that allotted to the grinding department, which is a necessary part of the scientifically managed tool room. It will be evident from a study of this plan, coupled with a reference to the general classification in Table I, that those sections are placed nearest the issuing and receiving windows which contain the tools in greatest demand. This reduces the number of steps of the tool room attendants and makes for greater efficiency in accordance with the principles of motion study. Modifications of this arrangement will of course suggest themselves in accordance with the needs of the particular plant involved.

Maintenance of Tools

As indicated in the introduction to this article, an important function of the tool room is the keeping of the tools in first class repair, and the grinding of them to standard shapes and angles. This is because the unit times on which the total time of each job is figured are based on tools in this condition. Therefore, an inspection bench and a repair bench are necessary parts of the tool room equipment, as are the various grinding machines shown in the plan, fig. 7. Drill and cutter grinders are well known, and have been used for a considerable period in many shops, which, however, still permit their men to grind their own lathe and planer tools. Only about one man in ten knows how to grind tools properly, and only about one-tenth of these men care to bother to do it. The loss in production due to machines standing idle while the machinist is grinding tools or awaiting his turn at the grindstone or emery wheel is much larger than is usually supposed. It probably is at least 5 per cent, if not more, and the overhead charges on the work go on while the machinist is thus idle. The heavy cuts required by scientific management can only be made with tools ground to the correct angles. This involves the use of a universal tool grinder and it is shown as part of the necessary equipment. Fig. 8 shows the recommended arrangement of the tool grinder in its relation to the light and to the receiving table and rack for finished tools. Formers for each shape of tool used in the shop should be provided as part of the grinder equipment.

The tools reaching the grinding department should be assorted on the receiving bench in accordance with their size and height, grouping similar tools together to save time in setting the grinder. It is uneconomical to grind tools singly or in small lots, and therefore the tool room stock of each shape and size of tool should be sufficiently large to permit the tool room to issue tools for a couple of days before the stock is exhausted, while tools are accumulating in the grinding department in sufficient quantity to warrant setting the machine for them.

The writer must again express his indebtedness to the Tabor Mfg. Co., the well-known manufacturers of molding machines, metal saws and tool grinders for the information and illustrations of this article, which are drawn from the practice in that company's shops.

NOMENCLATURE OF MACHINE DETAILS

By OBERLIN SMITH

PRESIDENT, FERRACUTE MACHINE CO., BRIDGETON, N. J.

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THAT the nomenclature of machinery, and of the tools and apparatus with which it is constructed, is, in this country, in a state of considerable confusion, scarcely needs demonstrating. If we look from an international point of view, and include the other English-speaking countries, Great Britain and her colonies, the confusion becomes worse confounded. A reform is destined, in due time, to come, doubtless to be promoted in great degree by such societies as ours. This reform movement cannot be begun too soon, and should aim at giving brief and suggestive names to all objects dealt with — each object to have but one name, and each name to belong to but one object. A simple method of beginning such a reform would be a common agreement among all our engineering schools to use each technical word in but one sense, and with no synonyms.

A lesser field of reform, and one which lies more particularly within the jurisdiction of individual manufacturers, is the comparative designation of a number of sizes or kinds of the same machine. There is now no common understanding whether a series of sizes shall be numbered or lettered from the largest down, or from the smallest up. The latter is undoubtedly the most natural and suggestive method, but usually becomes confused by want of careful forethought (when starting a series) in providing "gaps" for the insertion of future sizes. If a numerical series has been already started, and becomes commercially established, the only systematic way to insert new sizes (either at the beginning or through the middle of the series) is to use fractional numbers. This, though awkward in sound and appearance, seems to be the only means of suggesting the comparative size of the article by its name. The use of arbitrary higher numbers between the others is, of course, worse than no numbers at all. The use of a series of letters does not supply this fractional loophole of escape — the euphony of A-and-a-half, K-and-three-quarters, etc., being somewhat doubtful. Another method in much favor is the use of " fancy " names, such as " diminutive giant," " eureka," " firefly," etc. These are far preferable to confused numbers, as they are not intended to convey any ideas between manufacturer and customer, and admirably succeed in their purpose. All this is a very difficult subject to deal with, and one in regard to which we can scarcely hope for any exact system. We can but point out to manufacturers two general principles to be followed: 1st, of leaving abundant *gaps* — that is, let a regular series run 10, 20, 30, 40, etc., instead of 1, 2, 3, 4, etc.; and 2d, of using the smaller numbers for the smaller objects. The first is similar in idea to the well-known Philadelphia house-numbering system, which has worked so admirably in practice, and which has been copied by numerous other cities.

The two foregoing paragraphs are intended respectively as but casual allusions to the technical and commercial nomenclature of machinery in general. The subject is too elaborate to be treated at length in this paper, the main purpose of which is to set forth the results of the writer's experience in establishing a system of names and symbols for all the component parts, commonly called " details " of machines, or, in fact, of any manufactured articles.

That some such system is necessary, no engineer who has attempted to manufacture machinery by the modern system of duplicate (or approximately duplicate) parts, will, for a moment, question. The necessity for a specific name for each piece, which name is not, never has been, and never will be, used for any different piece of the same or any other machine, is evident, simply for purposes of identification. This identification is required mechanically at almost every stage of production. The name, or a symbol representing it, should be marked upon the drawings, the patterns, and the special tools pertaining to each piece, and, when convenient, upon the piece itself. Commercially, it is required on time cards and in indexes and pattern lists and cost books, as pertaining to production. Pertaining to sales these names or symbols must appear in illustrated price lists, and in orders by and charges to customers. This our modern method of repairs, by selling duplicate parts, renders imperatively necessary.

The requisites for a good system of names and symbols are: (1) *Isolation* of each from all others that did, do, or may exist in the same establishment. (2) *Suggestiveness* of what machine, what part of it, and if possible, the use of said part — conforming, of course, to established conventional names, as far as practicable. (3) *Brevity*, combined with simplicity. Of the importance of isolation to prevent mistakes and confusion; of suggestiveness to aid the memory; of brevity to save time and trouble, it is hardly necessary to speak.

Regarding the systems now in use in our best shops, this paper will not attempt detailed information. It is understood that the names are more or less scientifically arranged; depending, of course, upon the amount of study and the quality of the brains that have been expended upon them. In cases where symbols are used, supplementary to the names, they usually consist of letters or numbers, or (oftener) a combination of both. Many of them (both names and symbols) fail in symmetry and suggestiveness, because little attention has been paid to the names of the machines themselves, as regards the serial consecutiveness, hinted at in paragraph 2d. The quality of brevity often suffers severely, because the name and symbol must, in most cases, each have the machine name prefixed, to secure their perfect isolation. The latter quality is rarely dispensed with, simply because the manufacturer's pocket would be too directly touched by the expensive resulting mistakes. A perusal of some machinery catalogues which give detailed lists of parts is very harassing to a systematic mind. They are apt to derive one part name from another, prefixing the latter as an adjective each time, until some such pleasant title as "lower-left-hand-cutting-blade-set-screw lock-nut" is evolved. If there are symbols provided, they consist of some unknown combinations of letters part way down the list, and then change to arbitrary numbers, or perhaps to nothing at all. It will often be noticed also that no particular order appears to be followed in numerical arrangement, similar parts being scattered at random through the list.

The scheme to be described further on has been evolved gradually from the experience gained in managing a growing machine business. This scheme is far from perfect, and is probably inferior to others which have not been made public; but it seems to answer the purpose aimed at, viz., a comprehensive and elastic system which will accommodate itself to an unlimited growth and any variation in quantity or kind of goods manufactured. This the methods we first tried would not do, being too limited in their scope.

It should be here explained that the word "we," as just used, refers to the above-mentioned machine works, with which the writer has long been connected; and the scheme in question will be spoken of as "our symbol system." To further define terms: "machine name" and "machine symbol" refer respectively to the name and symbol of the whole machine, or other article of manufacture, for it will be noticed that the system is applicable to almost any products, except those of a textile or chemical nature.[1] "Piece name" and "piece symbol," in like manner, refer to the separate pieces of which the whole is composed. The terms "detail," "part," and "piece" have so far been used synonymously. It is doubtful which is really the best to establish as a standard, but we have adopted "piece," as best expressing the idea of one piece of material, reduced to the last condition of subdivision. In our practice exceptions are made to this requirement of homogeneousness in such cases as chains, ropes, belts, etc., — also material glued or welded together, — in short, anything which may (like a man) be called *one piece*, because it is not intended ever to be taken apart. The character for equality (=) will be used to show connection between a name and its symbol. A brief glance at the history of our system shows that at first we (like many others) hit upon the plausible idea of using numbers for machine symbols and letters for piece symbols. The numbers were somewhat "gapped," but not to

[1] There is no necessity for this exception, if the system is developed as illustrated in C. B. Thompson's "Classification," p. 461. — Ed.

such an extent as we now should practise. Examples: If four sizes of pumps were symbolled 1, 2, 3, and 4, their barrels might = 1–A, 2–A, etc., and their handles = 1–B, 2–B, etc. If the next product made was a series of lathe dogs, they would probably be symbolled 11, 12, 13, etc. Their frames would = 11–A, 12–A, etc., and their screws = 11–B, etc. This all worked beautifully until the products became so complicated as to contain more than twenty-six pieces! After tampering a little with the Greek alphabet (which seemed calculated to scare our new workmen), and trying to use a mixture of small and capital letters (which looked too near alike), we fell back upon the clumsy device of repeating the alphabet, with letters doubled or tripled.

When we finally abandoned the above plan, several methods were carefully studied. The next most obvious was to use letters for machines and numbers for pieces. This allowed any quantity of the latter, but limited the machines to twenty-six, even with no gaps provided. A certain modification of this method is, perhaps, more in use than any other system. In it letters are used for different sizes or styles of a certain kind of machine, and used over again for some other kind, *ad infinitum*. This answers the purpose, because there are not likely to be more than twenty-six varieties of one machine. It has, however, the fatal objection of requiring the whole machine name prefixed to each symbol, in all cases where the symbol stands alone, and does not happen to be written with the others of the set in tabular form. As the general name of a machine usually consists of at least two words, a complete piece symbol becomes too long for convenience in labelling. Examples: Force pump, K–26; lathe dog, H–2.

Another system consists in using numbers for the machines and numbers for the pieces. This gives isolation and brevity, but no suggestiveness. A serious objection to it is the danger of blurring the numbers together or of transposition in writing or reading them; also in the fact that either number cannot be used alone, as it can in the case of letters and numbers.

A similar system to the above consists in the use of letters for both symbols. It has the same disadvantages, and the additional one of a limitation in the quantity of letters at disposal.

Our system, as finally decided upon, is as follows: *Machine names* and *piece names* are determined by the designer, in general accordance with the principles already pointed out, being, of course, made as brief and suggestive as possible, with no two machine names alike and no two piece names alike in the same machine. In this nomenclature no positive laws can be followed but those of common-sense and good English. A *machine symbol* consists of a group of *three* arbitrary *letters* — capitals. A *piece symbol* consists of an arbitrary *number*, and follows the machine symbol, connected by a hyphen; thus FPA–2 might symbolize the force-pump handle before alluded to — smallest size. The machine symbol may be used alone when required, as FPA.

As thus described, these symbols fully possess the qualities of *isolation* and *brevity*. To make them also *suggestive*, some attention must be paid to what letters to use. In practice, we aim to make the first two letters the initials of the general name of the machine, and the last letter one of an alphabetical series which will represent the sizes of the machine. An example of this is shown in the symbol for the smallest sized force-pump, FPA. If there is any chance of a future smaller or intermediate size, gaps should be left in the alphabetical order. This " initial " method cannot always be strictly followed, because of such duplicates as FPA for force-pump and foot-press. The remedy would be to change one initial for one beginning some synonymous adjective; that is, foot-presses might be symbolized TPA, assuming that it stands for treadle-press. Usually the least important machine should be thus changed. From this it will be seen that, in defining the theory of this scheme, the words " arbitrary letters " were purposely used. The idea is to make the system thoroughly comprehensive. There might be such a number of machines having identical initials that the letters would be almost arbitrary. In practice, the designer can usually succeed in making the symbols sufficiently suggestive.

In considering how many letters to use in a symbol, considerations of brevity advised two; suggestiveness, three or four. Two letters did not allow of enough permutations nor indicate well enough the kind and size of machine. Three seemed amply sufficient in the first respect, as it provided over 17,000 symbols. If, for any reason in the future, four letters should seem desirable, the addition of another would not materially change the system. If three letters, hyphened to a number of one, two or three digits, should seem bulky, remember that this symbol can stand by itself anywhere and express positively the identity of the piece. Its comparative brevity is shown by comparing the second and third columns of the following table (A). In the different lines an idea is given of the application of the system to a variety of products not usually made in any one shop.

TABLE A

Col. 1st	2d	3d	4th	5th	6th
Full name of machine and piece	Our symbol for it	Symbolic name as often used	Characters in col. 2	Characters in col. 3	Excess of col. 5 over 4 ....
6″ x 4′ engine lathe, spindle head .	E L A-4	Engine lathe, A-4........	4	13	9
No. 4 power press, frame........	P P D-1	Power press, D-1........	4	12	8
7″ x 14″ steam engine, crank shaft	S E G-51	Steam engine, G-51......	5	14	9
Buckeye mow'g mch. left axle nut.	M M D-81	Mowing machine, D-81...	5	16	11
No. 3 glass clock, main spring ...	G C C-105	Glass mantel clock, C-105.	6	20	14
One-hole mouse trap, choker wire.	M T A-3	Wooden mouse trap, A-3..	4	17	13

Table B is a specimen of part of a page of our "Symbol Book," in which are recorded any machines which have arrived at such a state of perfection and salability as to be marked "Standard" on our drawings.

TABLE B

FPL		No. 3 Foot Press			Weight		482
Piece number	Same as	Piece name	Material	Quantity	Rough weight	Finished weight	Aggregate finished weight
1		Frame	Cast iron	1	220	200	200
2		Gib	"	1	10	9	9
3		Slide bar	"	1	45	40	40
4		Front leg	"	2	30	30	60
5		Back leg	"	1	40	40	40
6		Treadle	"	1	17	15	15
7		Lever	"	1	85	80	80
8	FPH- 8	Lever weight	"	4	5	5	20
9		Pitman	"	1	12	10	10
10	FPH-10	Clamp sleeve	"	2	3	$2\frac{1}{4}$	$4\frac{1}{2}$
21		Lever pin	Steel	1	$2\frac{1}{4}$	2	2
26	FPJ-26	Treadle and Pitman bolt	Iron	3	$\frac{1}{2}$	$\frac{3}{8}$	$1\frac{1}{8}$

This table almost explains itself. The piece numbers in first column do not have the letters prefixed because the latter stand at the top of the column. " Same as " means that the piece is identical with a piece belonging to some other machine, and can be manufactured with it. If it is common to several machines in a set, the smallest of the set in which it occurs is given. The " quantity " column tells the number of pieces of a kind required. The last " weight " column, added upward, shows total weight of machine. The piece numbers are " gapped " after each kind of material, and also at the ends of " groups," as described further on. This is to allow for future changes and additional pieces; also that other nearly similar machines, having more pieces, may, in general, have the same piece numbers.

The order in which the pieces are numerically arranged cannot follow positive rules in all cases. In our list of instructions (too long to be here quoted)[1] we direct a classification by *materials*. In each class we group pieces of the same general character, in regard to the prevailing work to be done upon them, and in natural " machine-shop " order; *i. e.*, first planning, then drilling or

[1] See F. W. Parkhurst's " Applied Methods of Scientific Management," which is based on the practice of the Ferracute Machine Co. — Ed.

boring, then turning. We also aim to place the heaviest and most important pieces first. Between each group we " gap " the numbers.

Regarding position in naming pieces, we assume a front to the machine (where the operator is most likely to be placed), and define direction tersely as " forward," " back," " right," " left," " down," " up." The adjectives of position prefixed to piece names are, of course, derived from these words, as " upper," " lower," etc. A perpendicular row of similar pieces, say five, would be rated upper, second, third, fourth, and lower. A number of different sized pieces of similar name may, in like manner, be prefixed smallest, second, third, etc.

Before closing, a brief reference to certain (two) supplementary symbols may not be out of place. One is a small letter after a piece symbol (as FPL–21–a), signifying that the piece is obsolete, the standard, FPL–21, having been altered. After a second alteration, the last obsolete piece would be suffixed " b," and so on. Thus duplicate pieces of old-style machines can be identified and supplied to customers. The other symbol referred to is to indicate the number of the operation in the construction of a piece, and is written thus: FPL–21–1st, FPL–21–2d, etc. Its use is of great value on detail drawings, time-cards, and cost records. It enables any operation (no matter how trivial), on any piece of any machine to be identified by a symbol alone. An *operation* we define as any work which is done by *one person* at *one time*, before passing the piece along and commencing upon another.[1]

[1] This article has been reprinted largely for its historical interest and the part it has played in stimulating an important development of the Taylor System: to wit, the classification and symbolization of all functions, costs, materials, and operations involved in industry. See C. B. Thompson's " Classification," p. 461. — ED.

CLASSIFICATION AND SYMBOLIZATION

By C. BERTRAND THOMPSON

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I

Giving a Business a Memory; How Materials, Processes and the Functions of an Organization are Given Places and Identities

It is astonishing that in all the discussion of scientific management that has been going on for so many years, and with such intensity in recent times, there has been practically no attention paid to the fundamental subject of classification. In the books on factory management, industrial engineering, cost accounting, and scientific methods of selling and production, you will find very little on classification. They give you classifications of their own; but the samples they give are good as suggestions and illustrations only. They will not bear transplanting. What they tell you is neither how they made them, or why they made them as they did. Especially do they fail to tell you how to go to work to make one for your own plant. To the busy, practical man this is the important and essential thing — how to do it himself.

The making of a classification is the beginning of wisdom. Without it accurate records are impossible; and where there are no records the business perishes. A distinguished professor of idealistic tendencies recently suggested to me what he thought was a new theory; that business ought to dispense with all records. Too much time is wasted, he said, in mere clerical work, and not enough spent on actual production. He thought it would be safe to get along without all this mere writing of history, and that society would benefit greatly from the increased production.

The only trouble with this theory is that it has been tried for centuries and found wanting. Business men are today being forced into more and more recording, because they have found that records are an indispensable insurance against mistakes, failure of memory, and against general human fallibility. Neglect of them means failure to get and to hold business. It means failure to work economically, and failure to deliver on time. It means inability to finance the business, because no bank will trust a concern which does not keep records. It often means failure to recover a just amount of insurance in case of fire. In a business of any size it means ultimate bankruptcy.

To get accurate records you must have classification for two reasons. In the first place, to introduce order and comparative simplicity into what is otherwise disorder and complexity. And in the second place, to identify all the elements of industrial activity.

Business activity is made up of three elements — materials, processes, and relations between individuals, the latter usually called organization. If you want to know what you are doing in your business — and if you don't the sheriff will certainly get you — you must reduce to order and identify every element of labor, every bit of material, and every detail of organization about your place, together with every relation between your business and the financial world and the market. And you can get neither order nor identification without classifying.

Consider how the natural sciences are built up on a foundation of classification. Biology has kingdoms, branches, classes, orders, genera, species and varieties. Each individual must fit in, as an individual belonging to a certain variety of a certain species of a certain genus, order, class, branch and kingdom. Every little insect has a location all its own. This is the only scientific way through the vast complexities of living matter. There is no other way to traverse the complexities of business.

Take for example a simple business like the cigar factory you can find in every town. The manager, who is also the selling force and one of the rollers, sits at a bench with the stripper and another roller. Their materials consist of tobacco of two or three kinds, cement, bands and boxes; their tools are boards, knives and baskets. Equipment is summarized in chairs and a table; perhaps a counter. The process consists in removing stalks, arranging filler and wrapper in parallel lines, rolling, cementing the tip, cutting off, packing, delivering. Selling is direct, to a few retailers. There is no advertising. The costs are not very complicated: wages, materials, and perhaps rent. Light, heat, and ventilation are such as a more or less benevolent nature provides. Efficiency is easily measured by output, so many boxes of cigars a day made and sold.

A small business like this, you would think, could be carried in the owner's head. But even this miniature manager feels that the small amount of record keeping necessary is justified by the risks he runs if those records are lacking. He has the rudiments of a bookkeeping system, therefore; he has a record of his customers, as well as of output. The risk is small; but so is the cost of keeping these memoranda. And even these few statistics require an elementary classification.

But to go from one extreme to the other, consider, for instance, an automobile plant. Here order becomes imperative. The mass of detail is overwhelming, until controlled by classification. Here you have engineers, draftsmen, designers, machinists, electricians, assemblers, testers, polishers, upholsterers, painters, chemists, besides large administrative and selling forces. Each department is made up of groups and individuals, each with its own separate and distinctive job. For materials — to mention only classes — you have iron, steel, brass, copper, nickel, wood, leather, rubber, paint, varnish, and numerous other minor groups.

Many types of buildings are required for different purposes: machine shops, woodworking shops, storerooms, stockrooms, offices. Your equipment must include machine tools of all kinds, a store full of small tools, and equipment for carpentering, upholstering and painting. The routing system must be efficient and therefore elaborate; for success depends on getting parts through in proper time and sequence for assembling, and the completed product out on schedule time.

Costs are enormously complex, and can be handled only by classification. Efficiency records must be kept, though the difficulty of recording efficiency is great because the elements are so numerous and varied, for without efficiency records it is impossible for a firm to compete successfully. The selling organization is for the time being the backbone of the automobile business, and selling cost is a large element in the price to the consumer. Failure to develop a highly efficient selling organization enabling him to sell at or above the market would mean ruin. In the up-to-the-minute sales department records are the breath of life. Without classification, there can be no records worthy the name.

Another interesting type of business, even more complex, is the construction and management company, which designs, finances, builds and operates public service corporations, power plants and factories. There are managers, engineers, draftsmen, carpenters, masons, concrete men, plumbers, electricians, technical experts, accountants, statisticians, stenographers, filing force, librarian, editor, financiers, bankers, bond sellers, agents, advertisers. There is every kind of material that can be used for office equipment, or on construction or field work. The routing is a large and important problem, first through the office and then in the field or the factory, and on all kinds of jobs. Costs are extremely complex, and they must be kept with the utmost accuracy; for it is getting to be more and more the rule with concerns of this sort to take contracts on a cost percentage basis. When the contract is of this nature the customer must have all the cost records submitted to him regularly and promptly; they must be detailed, up to date, and instantly accessible. He must also be shown that the costs are being kept down: efficiency records must be maintained. Both parties must know exactly what the total costs are, in order to fix the proper compensation when the final bills are rendered.

In such businesses as these — the automobile industry and the construction and management company — the risks of ignorance are simply enormous. An ounce of knowledge is worth a pound of guesses; a stitch in time saves nine law suits. Insurance at any price is cheap.

This is one of the necessary costs of doing business on a large scale, and society must submit to pay for it if it wants the advantages (probably compensating) of large scale production. It is also a necessary cost of any complex business, whether on a large or a small scale. In any concern that has passed beyond the one-man stage there must be plenty of records; to have them properly kept, classification is absolutely indispensable.

Classification and order mean, in the first place, definiteness of function. Every body knows exactly what he has to do, and how he has to do it: there is definite organization. It means definiteness of operation: everything is done at the time it should be done, in the order in which it should be done, and in proper relation to other things. It means convenience in locating the materials used and the records compiled. It makes possible accurate knowledge of costs. The disadvantages of doing without this classified knowledge are so great, and the advantages of having it are so many and important, that the question of expense sinks into the background. It is a necessary cost, like the cost of labor and materials and machines. One must expect to meet it when one undertakes any kind of business that is too big for one man's head. It goes without saying that this cost, like all others, must be kept as low as is consistent with real efficiency.

After the introduction of order the second function of classification is the identification of the elements and the combinations of labor, materials and organization. It is a curious fact that mere names are not sufficient for definite identification. Language has not grown so fast as the facts with which humanity has to deal. Consequently names are considerably overworked. They are ambiguous; they may at once mean two or three or a dozen or twenty different things.

The fact is that names get a definite meaning only from their context. The context is itself a part of the name; it is the significant, defining part. The usual way to get sharpness and definition is by a long, roundabout qualification and description. The short, direct way to provide a context which will make names significant, definite, unmistakable and intelligible, is classification.

Suppose you are doing business with twenty thousand customers. There are perhaps two hundred Smiths among them. You classify them first by their initials. But there are probably a number with the same initials, and some perhaps with even the same full name. You do not depend on their names alone; you have their addresses, and by supplying your customers with a context by their location, the state, city, street, and house number, you can ship and bill them without mistake. You identify them by this system of classification.

Your foreman sends in a requisition for five hundred feet of "tubing." This does not mean anything until you know what it is for. If you are in the automobile business, and the tubing is for coat rails, it may be brass; if for acetylene feed pipes it will be rubber. You must classify.

You want some one to "go to the bank and get some money." To finance a new departure in your business, your president or manager needs to make the trip. To get a check cashed for the week's payroll, however, a messenger will serve. Classification by function tells you which to send. You may call this common sense; but when you have ordered and classified all your common sense of small things you have the foundation for a science of business.

What classifications are of practical use to you in your business? There is apparently no end to the groupings which can logically be made. Out of these we must select those which show promise of practical usefulness. The chart on page 469 includes those which every establishment hoping to succeed must develop to some extent, consciously or otherwise. Many of them have already been reduced to writing in your factory or store perhaps; you have at least a system of classified commercial accounts.

Classified cost accounts are generally acknowledged to be useful; wise men know they are indispensable; and in many factories they are complete and adequate. Stores and stock accounts, under the guise of "perpetual inventories," have been injected into many stores and factories. Filing systems for records, at least for letters and orders, are quite common. They may be crude and incomplete, and only slightly related to other classifications and records; but the beginning is there. Drawings, blueprints, photographs, patterns, samples and catalogues still present a problem in too many shops; but they are filed in some way. The trouble does not come until some one tries to find where they were filed. Progressive managers, in order to collect statistics covering the vital phases of production, advertising, sales, employment and efficiency, have made the classifications necessary for these.

Routing, including the naming and location of all stores, parts in process (worked materials), tools, machines and work places, ought to be classified wherever assembling is a process; but there are few factories which do it thoroughly. Selling departments have done better. Their statistics of agents, territories, branches, and other methods of selling correspond to the routing which ought to be done in factories.

Classification of duties and functions has not been carried so far. The duties of every one, from the messenger boy to the president, are included in functional classification. Carried to completeness, it includes also processes and methods in current use. The functional classification is in fact the all-inclusive classification. It unifies them all; and, as will be shown later, it is the basis of a system which is an extraordinary saver of time and energy. The chart illustrates how all the other classifications are included under it.

How much classification should you do in your own business, and how can you do it? This section will attempt to answer only the first question; succeeding sections will set forth several answers to the second.

The extent to which you will make definite classifications on paper depends first on the nature of your business. For instance, it would be almost a waste of time to develop an elaborate routing system in many cases. This is true of those industries which are mainly analytical or continuous in their nature, handling a single material such as cotton, from start to finish, and modifying it in process. On the other hand, an assembling industry, like an engine works or a furniture factory, is utterly at sea without a good routing classification.

The probability of growth must also be considered. If your business is constitutionally stagnant, it makes no material difference what classifications you have or whether you have any. If you want to get it on the road again by heroic efforts, you will probably need them all. If your business is growing at a normal rate, you will need properly arranged records of many kinds, and your classification should be so comprehensive from the start that there is opportunity for unlimited expansion. A functional classification like that illustrated in the chart on page 469 should be the basis, as this unifies all the classifications, and is easily developed as the business demands additions.

The type of management also cuts a figure. Under the ordinary rough-and-tumble organization almost any classification will do. If such a management had a good system it might not know how to use it. As the management improves, the best methods become more worth while. Only the best type of management makes the most of the best system. It takes a high grade of ability to develop and to use a complete, logical and practical classification. Unless the management has that ability, or can hire it, it would do better to be modest and take its chances with a less elaborate scheme of classification. This is a hard saying; but business is frequently hard.

The two controlling considerations, however, are the necessity of insurance against error, which has already been discussed; and the incentive to standardization which invariably accompanies the effort to classify details. *Standization* is here used in the special sense of *the determination of the best method or the best material to use for any given purpose, and strict adherence to that best as the standard until a better is found.* You do not want to classify things and put them down in permanent records until you are satisfied that they are the best known for the purpose. You begin to standardize at the same time that you begin to classify and record.

This by-product of classification is of the utmost importance, and it is a safe prophecy that it alone, in the hands of a competent and wide-awake management, more than pays for the cost of even the most elaborate system. A functional classification of one office revealed that any one of four stenographers might

- FUNCTIONS
  - PRODUCTION
    - Charging
      - Operations
        - Productive
        - "Non-Productive"
      - Materials
        - Raw Stores
        - Worked
        - Finished Stock
    - Routing
      - Operations
      - Materials
        - Raw
        - Worked
      - Tools
      - Machines and Workplaces
    - Filing
      - Correspondence
        - Purchases
        - Employment
        - Customers
        - Miscellaneous
      - Information
        - Processes
        - Classifications
        - Materials
        - Accounts
  - SELLING
    - Charging
      - Administrative
      - Sales
        - Customers
        - Stocks
    - Methods
      - Agents
      - Territories
      - Branches
      - Mail Sales
      - Advertising
      - Packing
    - Filing
      - Correspondence
      - Accounts
      - Data

answer the telephone, with consequent interruption of all of them whenever the bell rang.

When you start to list and group materials, you usually find that the kinds and quantities of materials used are subject to the whims of the requisitioner or purchasing agent, or the state of the market. Yet you know that, ordinarily, for any given purpose, one material is better than another, and should be consistently used. When you must classify, you put down the one best material, and strike the others off the list, thus establishing a standard. This process saved a great university $7,000 a year on the cost of its stationery and office supplies alone.

As to methods, you will not take the trouble to study a process and reduce it to writing for the guidance of your present and future force, unless you are reasonably sure it is the best one you can get. Similarly with equipment. One of the Government departments at Washington was once subjected to a classification of the pens it used, and seventy-six varieties were found. There was no necessity, from any point of view, for using more than seven or eight kinds; and in the meantime the economy of larger purchases was sacrificed.

It were useless to inquire into the reasons for the neglect of classification, a neglect all the more surprising in view of its vast importance. As we have seen it lies at the foundation of modern business practice. Without classification, there can be no order, no definite identification and, therefore, no accurate records. Without records, business has no insurance against mistakes and forgetfulness, and it misses the opportunity and the incentive to adopt the best methods which come with the mere act of recording.

II

Memory Tags for Business Facts; What a Right Classification System Does for a Factory or Store and How to Make One

The correct method of classification is summed up in two words: analysis, the enumeration of elements; and synthesis, the regrouping of details.

To begin, you list all the facts of your business, every detail and element, down to the last paper of pins and the last stamped envelope. Each bit of material in stores, in process or in stock, each machine, tool, work-place and operation, each bit of income and expenditure, and the duty of each official and workman. At least this much must be definitely on paper and in your mind's eye before you can begin a comprehensive classification.

In practice you will not actually classify all these at once, of course. But to be in position to make ultimately a complete and unified classification you must see that the field is staked out from the beginning, even if it is only in outline. You are really writing your own insurance policy; and it is up to you to see that nothing of value is left off the list. It is the things you forget that always make the trouble.

Next comes the regrouping of all these elements into the classes to which they logically belong. Each element must find its appropriate place, according to the purpose of the classification.

If, for instance, you are dealing with functions, you will group the duties of the directors in one place, those of the executives in another, those of the workmen in another, dividing the latter up by departments or by the kind of work they do. In handling charges, you will start with the old favorite division into direct and overhead expenses, and then subdivide these into labor and materials, and shop and general expense, subdividing the last group to suit your taste. Your routing classification will include operations, materials, parts in process, machines and work-places, and tools. When these are done the filing classification, as will be shown later, will take care of itself, for it is nearly identical with those already suggested.

Certain items will appear in more than one classification; but there is no cause for alarm in this. Instructions for the operation of a monotype keyboard may be in the functional classification for details of method; in the routing classification for checking progress of work; in the charging classification for proper allocation of expenditure; and in the filing classification for reference to data. The same facts are differently classified for different purposes. They appear under the same name or symbol in all the lists; no confusion, therefore, results.

Everything will go well if you are logical and accurate from the start. The basis of classification is the similarity of certain elements in the things grouped together as "alike," and dissimilarity between certain other elements which distinguish one class from another as "different." Men are classified as animals, like the apes, on account of numerous similarities of structure; but they are distinguished as men by the few points of difference. Men are classified into races by including all with the same color of skin or the same shape of the head together in the same race, and all of different colors of skin or shapes of head in other races.

The elements of similarity or of difference chosen for industrial classification must be significant and essential; significant with reference to the purpose of the classification, and essential in the nature of the object classified. If you are classifying pencils with reference to charging them as direct or indirect expense, it is immaterial whether they are blue or not. If they are classified functionally, with reference to the purpose for which they are used, it makes considerable difference whether they are blue or black. The blueness is accidental in the first case, significant in the second.

Now that, with the aid of these few simple principles, you have corralled all the elements, and have rounded them up in logical and accurate pens to suit your needs, you must brand them with marks which will make them capable of easy identification. A classification is no good unless you use it, and use it constantly. To use it conveniently, some system of naming the elements must be provided.

These tabloid names are called symbols. A name is itself a symbol: "desk" is the symbol for this thing I am now writing on. When I want to designate a detail, such as the lever in the lock in the upper left-hand drawer of this desk, ordinarily I must use just this set of words. But this is too long for practical purposes, especially if I had to designate it very often, as I might in the manufacture of locks. This name must be shortened into a symbol, which will mean exactly the same thing at all times and in all places and never anything else. This symbol, since it is a short-cut, must be easily handled and, if possible, easily remembered.

A good system of symbols must have four qualities: First, simplicity combined with efficiency, with the emphasis on the efficiency. Simplicity in itself is no virtue; in the attempt to handle complex conditions it may be a vice. You are a canny manager, and you demand simplicity; when you go to the office in the morning you use the simplest vehicle you can find, to wit, a wheelbarrow, with your janitor or gardener for motive power. Or perhaps I am mistaken: you really prefer efficiency to simplicity, and go in an automobile, the height of complexity. In the same fashion, a system of symbols should be as simple as is consistent with efficiency. Many concerns still use a simple number system, running consecutively from one to a million — as simple as a wheelbarrow.

The second requirement is definiteness. There must be just one symbol to one thing, and one thing to one symbol, and the twain must be one. It ought not to be necessary to put your finger on a thing in order to identify it. That is, of course, the time-honored way, still used. Men will say: "Order a desk like this" or "a ream of stationery like that," notwithstanding that in nearly all other relations of life language has carried us beyond the pantomime stage. Classification has given the name perfect definiteness of identification; the symbol should have this same definiteness.

Third, the symbol should have a mnemonic quality; that is, it should be capable of being easily remembered. This is of the greatest importance. It makes symbols convenient and easy to handle without constant reference to a key. It serves as a check on accuracy; if a symbol is incorrectly made, the next person reading it will notice that it means nothing. A mnemonic symbol which follows the classification of the thing symbolized, sums up that classification in itself, as will be shown in a moment, and is, therefore, a perfectly definite and logical means of identification.

Finally, it must be brief. Practically this offers no difficulty; for any symbol is certain to be briefer than the name for which it stands, to the extent of from one-third to one-twentieth the number of letters. Here is a choice specimen from a catalogue: "Lower-left-hand-cutting-blade-set-screw-lock-nut" — a full-blooded linguistic dachshund. A perfect symbol for that could not consist of more than eight or ten letters.

The system which seems to me to meet all the tests laid down, yet comprehend the whole scope of industrial activity, is a combination of letters and numbers, predominantly mnemonic, which has been worked out mainly by Frederick W. Taylor and his group of associates, especially Carl G. Barth, together with some extensions (in the domain of selling organization) by the writer.

This system is based on a complete and exhaustive analysis of every detail of labor, materials and organization involved in a business, as previously explained. The resulting list of elements is then regrouped in a logical classification; first into broad general divisions, then each division into its subdivision, and each subdivision into as many groups and sections and subsections as the nature of the business requires. Letters are used for each division, subdivision, and so on. Wherever possible they are made suggestive, either by the use of the initial letter of the name or some other significant letter, or by being always used for the same thing.

Numbers are used for dimensions or for job or lot numbers, depending for their meaning on their special position in the symbol. Numbers are also sometimes used for the individuals in a class, as these ultimate elements are often so numerous as to go beyond the possibilities of the alphabet. They are also used at the beginning of symbols for operations, to indicate the first, second and succeeding operations on the piece symbolized.

Obviously the same letter will often be used for different things, according to whether the thing is a division, a group or a section. Its particular meaning, therefore, depends upon its position in the symbol. In the symbol ASAMP the first A has a meaning as part of a division, the second A another significance as part of a group. It is just as it is with digits, which in the decimal system get their significance from their position in the group. Thus 333 means 3 hundreds, 3 tens and 3 units. There is no reason for confusion in one system more than in the other; and no one would read this combination of digits other than as three hundred and thirty-three.

To make all this clear, suppose we construct a functional classification, taking for our example a small printing plant. This classification will include all the activities of the plant, productive, administrative, and selling, and will be broad enough to use for all purposes: costing, routing, control of materials, duties of officials, methods of work, sales organization, and filing. We shall select one item to classify and symbolize: the instructions for the operation of a monotype keyboard.

It is clear that in the broadest view, our business consists of manufacturing, selling, and the administrative and auxiliary activities connected with these. Auxiliary activities are those which are directly connected with production, such as power and light; administrative are those which are necessary to the conduct of the business, but do not enter directly into the product, such as accounting.

For convenience we shall break up manufacturing, for our general classification, according to classes of product, and will also segregate stores and materials and the operations and accounts connected with the purchase of land, buildings, new equipment and tools. This utilizes more letters for broad classes, shortens the symbol, and is an aid to accounting. Then we set down the letters of the alphabet in column, omitting the I and the O on account of their similarity to the figures representing one and zero, and fit our classes in. To continue the classification of manufacturing, D, by departments:

DC	Composing Room	DP	Press Room

Analyzing the composing room, DC, with reference to various features, we get:

DCA	Composing room functions not elsewhere classified	DCM	Machines and work-places
		DCR	Reclamation of errors
DCB	Miscellaneous labor	DCS	Stores
DCC	Fixtures, furniture and apparatus	DCT	Tools
		DCZ	Buildings

The next step is easy: DCM, machines and work-places, includes:

DCMF	Proofreaders' tables	DCMS	Imposing stones
DCMM	Monotype machines	DCMT	Type stands
DCMP	Proof presses		

Monotype machines, DCMM, divide naturally into

DCMMC Monotype casting machines   DCMMK Monotype keyboards

Operation is obviously P, so the symbol we are seeking is

DCMMKP Operation of monotype keyboard.

We can go on as far as we like in the analysis of keyboard operation, for tabular work, straight composition, justification, and so on.

This symbol is a complete classification and identification in itself. The instructions in question are evidently for the operation, P, of the keyboard, K, of the monotype, M, which is a machine, M, in the composing room, C, which is part of the manufacturing, D, end of the business. The symbol identifies the machine for the routing department, indexes the instructions in the methods of work, shows the accounting department that any charge in connection with these instructions is a manufacturing indirect expense, and provides the filing department with a self-indexing system for filing all data on the subject.

Almost every manager has been driven at times to some variety of symbolizing. It is usually some expedient gotten up on the spur of the moment for some special purpose, such as identifying costs or salaries, or shortening names of frequently used items. There are, however, a few serious attempts at systematic symbolization, besides the one just described, which it is worth our while to consider and to test by the qualifications laid down.

There are several arbitrary systems, some of them made up entirely of numbers. One manager symbolizes the parts of a machine by dividing it first into groups and numbering them consecutively, and then dividing each group into its elements, also numbered consecutively. In the wheel group, which is the fourth, there are front hubs, front flanges, and so on. These are symbolized thus: 4/1, 4/2, and so on. The classification here appears to be practicable, and it is easier to write " 4/1 " than " front hubs."

Brevity, however, is the only advantage this method of naming has. It is not definite, for it does not, without further description, indicate what type of machine the hubs are for. It is therefore not really simple, and it not mnemonic. A similar system has been proposed for identifying costs: (1) Annealing; (2) Assembling; (3) Babbitting; (4) Bending; (5) Blowing; (6) Boring, and so on. This is subject to the same adverse criticism, besides being based on no logical classification at all.

Many managers use a system which is an arbitrary combination of numbers and letters. For instance, one symbolizes departments thus: A, Administrative; B, Legal; C, Business, general office; D, Sales; E, Accounting; F, Purchases; G, Engineering; H, Drawing; I, Planning, and so on. This is used to identify workmen, and departmental expenses. Thus 4G is workman Number 4 in the engineering department; G4 is a subdivision of engineering expense. A well-known accountant symbolizes private ledger accounts by the same method. A to D is assets; E to H, liabilities. Cash is A1; Notes Payable, 1E. These are all short, definite, and comparatively simple; but they lose all the advantages that would accrue if they were suggestive.

Sometimes you find a combination of arbitrary and mnemonic characters in a symbol. Sometimes an effort is made to give mnemonic quality to numbers alone by grouping them. This has been applied especially to the classification of expenses. Thus one man gives this for a foundry: Direct labor, 150 and 151; various expenses, 152 to 160; Supplies, 165 to 169; Maintenance, 170 to 175; Departmental expense, 180 to 187; Miscellaneous, 190 to 194; Commercial, Administrative, 200 to 207; and Commercial, Selling, 215 to 220.

Another large establishment groups, somewhat less minutely, into Administration Expense, 101 to 149; Selling Expense, 151 to 179; Distribution Expense, 181 to 199. This system is short, definite, slightly mnemonic, and simple — too simple, in fact. Those using it must either memorize the meanings of groups and of single numbers, or else be constantly referring to a key. It is therefore inconvenient to handle.

The group idea is carried to its logical conclusion in the Dewey decimal system, well known from its use in public libraries. This apparently elaborate system, when applied to a logical classification, is in fact simple; and when frequently used it is highly mnemonic on account of its strict logical associations. It is brief and very definite. It can be applied to the filing of any data in an industrial or commercial establishment, simply by making a basic classification to fit the case; as for instance for catalogues, clippings, drawings, memoranda, and so on. Its great disadvantage is that its use is practically limited to filing.

We saw that by the Taylor system the symbol for the instructions for the operation of a monotype keyboard would be DCM-MKP. Let us compare this with what it might be by some of the methods just described. By one method it might be 233; by another, 17/11; by another, J6; by another, 14C (slightly mnemonic); all of them short and fairly definite, but too simple to be efficient, and in most cases not in the slightest degree suggestive. Another method might symbolize it MON4, which would be better than any of the others. The Dewey system would perhaps call it 677.823.19. Most of these systems could not classify and symbolize such a detail at all, except in a purely arbitrary fashion; and such a symbol as they could get would necessarily have an exceedingly restricted use.

The advantages of the Taylor system are first, that it is absolutely definite; for the moment you introduce a new factor in the thing you have to change the symbol, hence you can have but one symbol at any one time for one thing. It is mnemonic, for the letters remind you of words whenever possible, and the arrangement in a logical classification indicated by the position of the letters in the symbol helps out your memory of their significance. That it is brief in comparison with the full name of the thing symbolized is obvious. It is as simple as is consistent with efficiency; and in practice is far simpler than other systems, on account of its qualities of definiteness and suggestiveness.

In addition to these advantages, the classification on which the system is based includes the entire business, and consequently the symbols used are applicable in every department and for every function, including accounting, routing, handling of stores and stock, checking progress of work, methods and details of selling, the filing of all records, correspondence and data, and the arrangement and location of materials, parts in process, stocks of finished goods, tools, machines and work-places. It is self-indexing, like a dictionary or a city directory; and this not only expedites the finding of any material, part, or record wanted, but greatly facilitates the handling of requisitions, time tickets, bonus tickets, and so on, for the costs department.

The time must come when a complete classification of all business will be made, similar to the Dewey classification of all knowledge. This is a task which calls for the resources of a Government department, or in default of that it should be undertaken gradually but with determination by our great universities. And when it is made, the details should be symbolized in accordance with the system advocated in this article.

Class Letter	Classification of Accounts General Grouping	Departmental Grouping	Detail Grouping	
A	Auxiliary →	AA	AHA	Wages of engineer and firemen; other labor connected with running of boilers, engines and other machinery in Engine Room.
B	Business (Administrative)	AB		
C	Selling	AC		
D	Manufacturing departments	AD		
E	Erecting	AE Experimental work	AHB	
F	Products (F–R)	AF	AHC	Fixtures and furniture; tools and minor equipment in Engine Room. Repairs and maintenance; not new work.
G		AG		
H		AH Heat, light, power		
J		AJ		
K		AK →	AHD	
L		AL	AHE	Engines, boilers, other machinery, line shafting, pulleys, belts in the Engine Room. Repairs and maintenance; not new work.
M		AM		
N		AN		
P		AP		
R		AR	AHF	Fuel, including freight cartage and receiving; also cost of disposing of ashes.
S	Stores, Raw Materials, Tools	AS Storeroom		
T		AT		
U	Products (U–W)	AU	AHG	Gas used throughout building.
V		AV	AHH	To AHP unassigned.
W		AW	AHR	Water Rent.
X	Part construction	AX	AHS	Stores and supplies including stationery.
Y	Machinery, motive power	AY		
Z	Land and buildings	AZ	AHT	to AHV unassigned.
			AHW	Piping and fixtures for steam, gas, and water throughout factory; also all electric wiring. Repairs and maintenance; not new work.
			AHX	to AHZ unassigned.

III

Taking Factory Costs Apart; How to Analyze, Classify and Charge Expenses According to What They Should Buy

It is probably too much to say that a business cannot exist without an adequate cost accounting system. Stores and factories have struggled along for years without it. There is a shoe store in a western city which has what some might call a model accounting system — that is, taking "model" in the sense of "a miniature imitation of the real thing." The owner, who is the buyer, chief clerk, accountant, and repair man, has one book — the ordinary ten-cent Manila-covered butcher-shop memorandum book. On the left-hand page he enters all expenditures, dated but unclassified; this includes such things as postage, wages, cartage, advertising, insurance, magazines, and also his personal expenditures. On the right-hand page opposite are listed all receipts, also unclassified; receipts from sales, repairs, interest on money loaned, and so on.

These columns are footed on each page, carried forward to the next, the grand totals taken at the end of the month, and the balance indicates to this man his profit or loss for the period. Depreciation, discount, and such details as that are too fussy for him to bother with. The store has been run on this basis for going on ten years; and the fact that, while he is doing a $60,000 business, he has on his shelves about $50,000 worth of shoes aged one to ten years has not thus far worried the proprietor.

It is too much to say that a man cannot live on one lung, just as it would be rash to assert that a store can't get along with such a system as the one just described. A man with one lung can get along. He lives; but his vitality is low and his life is comparatively short.

Most people, nevertheless, if they have a choice, prefer two lungs. So the business that wants to be healthy and long-lived prefers some accounting system which is at least sufficient for its needs. Our friend's shoe store, for example, can hardly get along permanently with a system which shows less than these facts:

Merchandise — gross sales, cost of goods sold, discounts taken on purchases; Expense — buying expenses, selling expenses, delivery expenses, management expenses and fixed charges, losses from bad debts, losses from errors and goods returned. Buying and selling expenses must include, of course, the salaries of the buying and selling force, extra premiums for selling and an itemized account for advertising. The wise manager deducts from gross sales all returns and allowances, unless those are covered by the factory from which he got his shoes. His cost of goods sold includes purchases at billed prices, with a separate account for discounts, and it also includes freight and cartage on purchases. Above all, the wise man does not neglect the item of depreciation and shrinkage. An imposing array of boxes of shoes is not an evidence of prosperity if those shoes really belong in a museum. Shoe dealers who make a specialty of novelties are well aware of the fact that 50 per cent is none too much to allow for depreciation. Some allowance has to be made even for staples.

Delivery expense must include salaries and wages of delivery force or the cost of delivery service by an outside company. Management expenses and fixed charges should include rent, heat, light, power, repairs and renewals of equipment, depreciation of equipment, insurance on stock and equipment, taxes and licenses, management and office salaries, office supplies and expenses, and anything else that cannot be charged in the items already given. And as a kind of symptom chart the losses from bad debts and cost of errors and goods returned should be kept separately with the object of forcing them down to a minimum.

You may have noticed that interest is not included in this analysis of costs. Raising this question will throw any convention of accountants into debate in a minute; and this is not the place to discuss the pros and cons in detail. I feel, however, that there is no more reason for including interest in cost than for including profits. If you put your money into business instead of loaning it out, your interest becomes profit. If you have to borrow part of the money to carry on your business, the interest that you pay the other fellow is part of the profits that you lose to him. Interest, like profits or dividends on capital stock, is merely a share of the net surplus after all bills are paid. This reasoning applies as well to a factory as it does to a store.

In a good many factories, all the costs are carried in the manager's head. This same manager's head also carries all the information in regard to raw materials, ordered, on hand, issued, needed. He also knows all about the time his orders are to be delivered, just what stage of development they have reached in the factory, what goes into them, and when and how. This wonderful head also knows all about the men employed; how long they have been there, how good their work is, when they are deserving of promotion or advancement in wages, and how they ought to do their jobs. The only thing its owner refuses to take a chance on is the money due from customers — here, at least, he is willing to admit that a paper record is better.

An X-ray analysis of the contents of such a head will show that it is made up of a jumble of general impressions about everything, with very little definite and accurate information about anything.

The man who knows the facts about his business is one who records those facts as they arise and classifies the information thus recorded. This is particularly true of factory costs. For cost accounting, though in principle comparatively simple, is in practice necessarily complicated, involving as it does many little and elusive items. As you have probably read before, costs like all Gaul are divided into three parts. There is the material that goes into your product, the labor that goes into your product, and all other material, labor and expenses that are necessary to carrying on the business but are not sold directly. The first two constitute your direct labor and material costs; the third subdivision is your indirect cost, otherwise known as "overhead" or "burden."

"Overhead" and "burden," however, are terms that ought to be discarded, for they suggest something in the nature of a weight or drag on the business.

These indirect costs in fact are at least as essential to the maintenance of the business as the direct. Probably your salary, you who read this, is an indirect expense; but you are not on that account any more willing to admit that you are not indispensable to the business. The brains of the manager usually get into the product only indirectly — if at all. A large ratio of indirect expense, therefore, may, contrary to the general impression, be evidence of high efficiency, provided of course the indirect labor is applied properly and economically with reference to the result to be obtained.

There is a small plant in Philadelphia which employed six years ago about a hundred men in the shop and six in the office. This looked like an ideal situation, so far as the proportion of "overhead" was concerned. The plant, however, was losing money and borrowing to make up a deficit. It applied for a loan to one man who named as a condition on which the loan should be granted, the requirement that the plant should be completely reorganized. This was accepted and the reorganization effected.

The concern now has about seventy men in the shop and twenty-five in the office — a proportion of overhead which would give most managers the nightmare. As a result of this re-arrangement, however, the company is now, with a smaller force, turning out three times its former product; and in spite of the lower market price of the article it manufacturers, its net income is two and a half times what it was. It has paid its debts and is now turning over a substantial dividend. So much for the real nature of "burden."

In analyzing and classifying your costs, the first thing to do is to find out what they are. You will have to depend on records and not on any man's head, however capacious. Material costs should be taken directly from requisitions, without which no materials should be allowed to go from the storeroom. These requisitions should give the quantity, value of the material, and the order number or the indirect expense to which it is to be charged. All work done in the plant should also be recorded either on a work ticket, which is the workman's authorization for expending his labor, or on some other kind of reliable record which records the amount of labor the workman has performed. This ticket or record should also indicate the order or the expense to which the labor cost is to be charged.

If you want accuracy in the allocation of labor cost, it is highly important that the time spent on each order shall be recorded by some one other than the workman, preferably by a clerk with a a time stamp. With the best intentions in the world, the workmen will shuffle and juggle times in order to make a clean record for the day, and they will also indulge necessarily in a considerable amount of guessing. Workmen's time tickets filled out by themselves run to round numbers, much as ages do when taken by the census enumerator. The lady of twenty-nine and three-quarters finds it most convenient to say "about twenty-five," as her sister of thirty-seven is apt to put it "about thirty." The workman who was not rushed and took an hour and fifteen minutes on a job is very likely to send in a record of an hour and a half, and away goes the accuracy of your labor cost.

When materials and labor are to be charged to specific products, there is no great difficulty encountered in allocating the cost. The trouble comes in connection with the materials and labor and supervision that are to be charged to indirect expense.

Indirect expenses are so numerous and varied both in factories and stores that classification becomes absolutely indispensable. Once made, this classification becomes most easily workable when reduced to a mnemonic system of symbols. In the rest of this article, therefore, such a plan and method of classification and symbolization, applicable with slight modification to practically any manufacturing plant, will be described.

Your first question is: "Is the product on which work is done to be sold ?" If the answer is "Yes," then the charge is a direct one against product or "worked materials," which will ultimately be sold as merchandise. If the answer is "No," then you must ask: "Does the work done or the material used increase the permanent value of the plant ?" If it is for land and buildings, or machinery and motive power, the answer is undoubtedly "Yes, and you will have two accounts: one for Land and Buildings, and the other for Construction. If it is for fixtures, apparatus, tools, and so forth, which depreciate rapidly, and on which it may be advisable to charge half the cost at once to Shop Expense, and the other half to Construction, you have an account for Part Construction.

If the work done or material used does not increase the permanent value of the plant, then it must fall under the head of General or Department Expense. There are some departments of your business whose work does not directly affect the product at all. For example, your accounting department and your selling organization; you can manufacture without them if you are interested only in making a product. You may charge one set of expenses then directly to the selling department and another set to what you may call administrative or business departments. Another class of your expenses is necessary to carry on the work of manufacturing such, for example, as power, storerooms, and toolrooms. Without them, the product could not be manufactured at all. And yet they do not enter visibly into the finished article to whose production they are so essential. These may be either general expenses applicable to the whole plant or departmental shop expenses applicable to one department or another.

Now suppose we lay out a base sheet. First, you arrange the alphabet in column, omitting I, O, Q; then you fit in the broad classifications already given, following so far as possible the mnemonic method. You may call the general expenses which are necessary for the manufacture of the product " Auxiliary "; administrative expenses may be termed " Business "; selling expenses may as well keep their own name; shop expenses may be called " Departmental "; you may also have an item for erecting, if the nature of your product is such that this is essential. These can go in at the top of the alphabet; and the last letters, X, Y, Z, may be for Part Construction, Construction, and Land and Buildings, as defined above. Your base sheet will then look like this:

A Auxiliary
B Business
C Selling
D Manufacturing Departments
E Erecting
F to R Products
S Stores, Raw Materials
T Tools
U to W Products
X Part Construction
Y Machinery and Motive Power
Z Land and Buildings

In order to connect this classification with other purposes of the factory than cost accounting, it is advisable to use S invariably as the first letter in the symbol for raw materials, developing the rest of the symbol in the manner to be indicated in a succeeding article. Similarly T is reserved for Tools in the plant, where they are an important factor. The other letters then may be used for classes of product: such as G for grinders, K for milling cutters, M for moulding machines, etc.; or K for coats, T for trousers, U for suits, V for overcoats, etc.

Then you will proceed to subdivide each of these items: for instance, your auxiliary group of expenses, A, might be further analyzed like this:

AA to AD Unassigned
AE Experiments for the benefit of manufacturing
AF
AG
AH Heat, light and power
AI to AR Unassigned
AS Storeroom
AT to AZ Unassigned

Then you will subdivide AH:

AHA Salaries or wages to the engineer and fireman when their work cannot be charged to any other expense item of this department, and any other labor connected with running of boilers, engines, generators, and other machinery in the Engine Room.
AHB
AHC Fixtures and furniture, both fixed and movable, and tools and other minor equipment in the Engine Room. Repairs and maintenance, but not new work.
AHD
AHE Engines, boilers, and all other machinery, including line shafting, pulleys, and belts, in the Engine Room. Repairs and maintenance, but not new work.
AHF Fuel, includes all materials used in firing boilers, inclusive of freight and cartage, receiving and cost of disposing of ashes.
AHG Gas used throughout building
AHH to AHP Unassigned
AHR Water Rent
AHS Stores and supplies including stationery, which cannot be charged to any other expense item of this department.
AHT to AHV Unassigned
AHW Piping and fixtures for steam, gas and water. Also all electric wiring, repairs and maintenance, but not new work.
AHX to AHZ Unassigned

The same kind of analysis should be made of all other items, including the product, which may be subdivided into the various kinds of grinders, milling cutters, or suits and overcoats made. To carry out this plan of classification in detail for a simple plant requires a small volume and is a task not lightly to be undertaken.

Such a classification must be made by each plant in accordance with its own specific needs, following strictly the funamental principles of approved cost accounting. When once done, however, it is done for good; and until it is done, the management must wander in outer darkness, so far as its costs are concerned.

If every expenditure of labor or material is made on a written order or requisition, the symbol of the expense and the order number should be on each one. When this is done, the cost department can have no difficulty whatever in properly allocating each cost. The allocation of direct labor and materials to the product made is easy; but the proper distribution of indirect expense over the product, where it must finally land and be paid for by the customer, requires experience and careful thought.

Of the various ways of doing this, each has its advantages and disadvantages. Unfortunately, it is not immaterial which one is chosen, as the adoption of the wrong method may result in disaster to the cost finding system. This question, however, is a matter for separate and extended discussion. Let it suffice now to call attention to the fact that there are at least a dozen reliable books on this subject now on the market, to say nothing of the swarm of "experts" ready at your call.

A cost system may be a thing of beauty in itself, but not necessarily a joy forever. For practical men, it must pass the test of usefulness. When an automobile company finds that each car is taking $90 worth of brass, where $80 worth will do, the cost system is worth $10 per car to it. If the costs show that a material costing $160 is used in each car, where another material costing $30 will do just as well, this system is worth $130 per car for this service.

A cost system constructed with sufficient minuteness and detail will call attention to just such facts, provided the management studies the costs as they come from the accounting department and reads them intelligently. Two things are here required: first, that the costs shall be detailed and accurate; second, that the management shall treat them as an integral part of the business and make them serve the purposes of the business as definitely as the labor he hires. A perfect cost system in the hands of an unobservant or unintelligent manager is useless and expensive.

If your system shows that 30 per cent of your stock is of a kind which depreciates at the rate of 50 per cent per year and induces you to clean out that 30 per cent as quickly as possible, it may be worth to you the difference between prosperity and bankruptcy. And here again you must get facts that are real facts and act on them with judgment and decision.

Many managers have found themselves borrowing from Peter to pay Paul — making up the loss on one product out of the profits on another. Handling a varied line of articles for each of which the market is different, there is danger of this. A cost system which differentiates between the articles sold and follows each class through from purchase to the settlement of the customers' accounts, can know which are profitable and which are not, and can cut off the unprofitable members. Failure to attend to this is the direct cause of the decline and fall of many a company.

Some manufacturers and dealers still cling to the old-fashioned idea that it pays to sell cheap and often, that a quick turnover at a small profit is better than a slow turnover at a large one. It is a detail worth mentioning in connection with this that the ultimate consumer thereby gains. The cost system in one automobile factory that enabled the management to cut off an even $240 from the price of one of its models was a comfort both to the manager and the consumer, and both had gained.

It takes as much judgment to know when to stop doing a thing as when to do it. A system of records which is indispensable at one time and for one purpose may be no longer needed when that time has passed and its purpose has been fulfilled. In most places a cost system, once developed, should be maintained; but there are plants in which it may be discontinued once it has established the cost of the product made. In a pottery factory, for example, manufacturing the same line year in and year out, getting its materials at the same price and able to account easily for varia-

Class Letter	Name of Classification General Grouping	Departmental Grouping Stores, Raw Materials S		Detail Grouping Classified Stores, for various purposes SV		Detail Division Inks and Inking Materials SVK		Detail Subdivision Printing Inks SVKP		Detail Sub-groups Black Printing Inks SVKPB	
A	Auxiliary	SA		SV-A		SVKA		SVKPA		SVKP 1 B	Regular Black
B	Bus. (Admin.)	SB		SV-B		SVKB		SVKPB	*Black* →	SVKP 2 B	Book Black
C	Selling	SC	Special stores for compos-	SV-C		SVKC	Copying	SVKPC		SVKP 3 B	Catalogue Black
D	Mfg. departmts.		ing room products	SV-D			inks	SVKPD		SVKP 4 B	Form letter Black
E	Erecting	SD		SV-E		SVKD		SVKPE		SVKP 5 B	Magazine Black
F		SE		SV-F		SVKE		SVKPF		SVKP 6 B	Process Black
G		SF	Forms, printed and ruled	SV-G		SVKF		SVKPG	Green	SVKP 7 B	Tablet Black
H			matter	SV-H	Hardware and supplies for	SVKG		SVKPH			
J		SG			maintaining plant (and	SVKH		SVKPJ			
K	Products	SH			equipment)	SVKJ		SVKPK			
L		SJ	Special stores for job	SV-J		SVKK		SVKPL			
M			work	SV-K	*Inks and inking ma-*	SVKL	Lamp	SVKPM			
N		SK			*terial* →		blacks	SVKPN	Brown		
P		SL		SV-L	Liquids, semi-liquids	SVKM		SVKPP	Pink		
R		SM			and solids used in solu-	SVKN		SVKPQ			
S	*Stores, Raw Ma-*	SN			tion, except inks →	SVKP	*Printing*	SVKPR	Red		
	terials →	SP	Special stores for press	SV-M	Mineral products not		*inks* →	SVKPS			
T	Tools		room products		elsewhere classified	SVKQ		SVKPT			
U		SQ		SV-N		SVKR		SVKPU	Blue		
V	Products	SR		SV-P	Paper, boards, etc.	SVKS		SVKPV	Various inking		
W		SS		SV-Q		SVKT	Time stamp		materials (ink-		
X	Part con-	ST		SV-R			ribbon		oleum and		
	struction	SU		SV-S	Office supplies not else-	SVKU			dryer)		
Y	Machinery	SV	*Classified stores used*		where classified	SVKV		SVKPW	White		
	and motive		*for various purposes* →	SV-T		SVKW	Writing fluids	SVKPX			
	power	SW		SV-U		SVKX		SVKPY	Yellow		
Z	Land and	SX		SV-V		SVKY		SVKPZ			
	buildings	SY		SV-W		SVKZ					
				SV-X							
				SV-Y							
				SV-Z							

tions in labor cost, once the cost of a line is determined, the system may be safely allowed to go into disuse, retaining only so much of it as might be necessary to ascertain the cost of a new line, if such should be taken on. The conditions under which such a policy would be safe are rare, and the best rule, when in doubt, is to keep your cost system. In any action to abolish it, the burden of proof is on the alleged exception.

IV

Listing Stock to Index Wastes; How Classification of Materials Cuts the Capital Investment and Insures a Constant Supply

On many subjects of business administration, the recent report of General William Crozier, Chief of Ordnance, to the Secretary of War is of commanding interest. There is one paragraph in this report bearing directly on the subject of this article. After pointing out the savings from improved shop management and premium system according to the Taylor methods of $240,461.93 in the last year at the Watertown Arsenal, there follows a paragraph on " surplus stock savings " which reads as follows:

" Inasmuch as scientific management more systematically directs greater attention to all details of manufacturing work than was previously bestowed, its trial by the department led to a closer study, among other objects, of the amount and kind of material that should be kept on hand for manufacturing purposes, with the object of reducing such stock to the lowest limit consistent with efficient and economical operation. The study given this subject resulted in the adoption during the past year of a uniform system for determining the amount of stock to be carried and for providing for its replenishment. The over-accumulation of stock is easily accomplished. Material is prone to be scattered through a manufacturing establishment in unimpressive lots and to rest in out of the way places unobserved.

" A careful determination under a scientific method of the proper quantity of stock to be kept on hand revealed the fact that in the case of many items the quantity had been excessive, and that the stock of those items could be greatly reduced. The process of realizing upon this surplus by using it in current manufacture was at once begun and will be continued until it is all absorbed. It will take several years to accomplish this. During the past year $122,789.61 worth of this surplus has been used. This means that the manufacture of the articles for which the surplus material was used was accomplished by the actual disbursement of $122,789.61 less than would otherwise have been required, so that that amount of money was available for additional work." He adds that "in the Springfield Armory there is a remaining surplus of $130,313.53 over and above that mentioned above."

Inasmuch as General Crozier's administration of the Ordnance department has been recognized as one of the ablest feats of management in the Government service, these figures and comments are all the more significant.

Statements like the above call to the mind of most managers lurid visions of invading swarms of experts and miles and miles of red tape. The longer some managers think of it, the redder the tape becomes and the paler the $122,000. Many managers reason thus: a system means overhead; overhead means disaster. This is the old-school way of thinking, which, it must be confessed, still predominates.

And yet a little systematizing which will save $122,000 in an institution doing $940,000 a year would presumably be worth some attention and might even justify some expense.

Suppose that, in addition to pointing the way to using up surplus stock, the system under discussion reduces the amount of stock that it is necessary to carry and thereby frees more capital. The manager of one of the best known and best managed concerns in the United States told me not long ago that in a certain department of his works, before he systematized his stores, he had tied up in his storeroom the equivalent of the year's output of that department. Since then the business of the department has increased fifty per cent, the storerooms have been systematized, and they now carry the equivalent of one-third of the year's business.

In another plant three thousand varieties of lace and embroideries were being carried on the shelves. The mere effort to classify these led the management to consider how many they could get along without, with the result that now less than three hundred are to be carried regularly. Even a little printing plant with about two hundred items of stores found that eighty-five of these were superfluous. Another plant which prides itself on its skepticism in regard to " system " maintains a special storeroom for " excess and obsolete stores." That is the other way to handle the problem.

The important point in connection with this is the fact that these economies came about as a by-product of systematizing the stores department. Every manager knows or has good reason to suspect that he is carrying more of some kinds of stock than he needs and less of others. In the one case he is tying up capital unnecessarily; in the other he finds himself short of some material or part just when he needs it for a special order. He knows that this undesirable condition is due to an absence of system; but what he does not know is how easy it is to systematize his stores and how inevitably the mere act of systematizing provides a remedy for these troubles. The fact of the matter is that the mere classification of raw, partly manufactured, and finished materials leads at once to a careful consideration of the real needs of the business and an immediate adjustment to requirements.

The classification is not the whole of the stores system; it is merely the beginning. Once materials are classified, they must be definitely and continuously accounted for; and they must be kept under strict control and issued on requisition only, as strictly as a bank controls and issues its cash. But a logical classification and symbolization is the indispensable prerequisite to a stores system, and this in itself was responsible for a large part of the savings just described.

To begin your stores system, you must get your definitions right. All the material in your place can be divided into two classes: that which is still in the same condition in which you purchased it, and that on which you have done some work. The first class we will call stores or raw materials. Notwithstanding the fact that when you purchase them they may be highly finished products, for the purposes of your plant they are raw materials;

Class Letter	Name of Classification General Grouping	Stores, Raw Materials		Classified Stores, Various Purposes	
A	Auxiliary	SA	Stores used for various purposes not elsewhere classified	SV-A	Stores not elsewhere classified
B	Business (Administrative)				
C	Selling			SV-B	Brass and products of brass not otherwise classified
D	Mfg. departments	SB			
E	Erecting	SC	Castings for chipping exercises		
F				SV-C	Iron castings and products of iron not elsewhere classified
G		SD			
H		SE	Special classification for exercises not elsewhere classified		
J				SV-D	
K				SV-E	
L		SF	Castings for face plates	SV-F	
M		SG		SV-G	
N		SH		SV-H	
P		SJ		SV-J	Belting, hangers, pulleys, and transmission devices not elsewhere classified
R		SK			
S	*Stores, Raw Materials* →	SL	Castings used for lathes		
T	Tools	SM		SV-K	
U		SN	Castings for engines	SV-L	Lubricants and liquids not elsewhere classified
V		SP			
W		SR		SV-M	Metals and their alloys not elsewhere classified
X	Part construction	ST			
Y	Machinery, motive power	SU		SV-N	
		→ SV	*Classified stores used for various purposes*	SV-P	
Z	Land and buildings	SW		SV-R	
		SX		SV-S	Steel and product made of same not elsewhere classified
		SY			
		SZ	Stores for constructing clamping or fastening devices		
				SV-T	Tools and implements not elsewhere classified
				SV-U	
				SV-V	
				SV-W	
				SV-X	
				SV-Y	
				SV-Z	

and for the purposes of cost keeping there is a material cost only on them, with the exception of some slight indirect expense for handling.

Of the materials on which you have done some work, some are finished and in the stockroom. These we will call stock as distinguished from stores. Others are partly finished and are either in process now or are temporarily stored for further processing. These we will call worked materials as distinguished from stores and stock. Inasmuch as finished stock is only worked materials on which no further work is to be done, the classification of worked materials develops into the classification for stock as will be shown later.

With these definitions in mind, the first thing for us to do is to list all the raw materials or stores in the place. We are not interested in values now. What we want is items and quantities and we want everything there is whether currently used or not. It is those things we are tempted to omit which we have been omitting for several years and which are accumulating and cluttering up the place as well as eating up interest on the investment.

I know one concern which, when it started to list its materials on hand, got together several carloads and disposed of them at once rather than burden the classification with them.

A permanent supply of some of these materials has to be kept. Unless you change your product, you expect your storekeeper to have these always on hand. Others, such as a desk or a typewriter, you purchase occasionally but do not carry in stores. It is hardly worth while to do much bookkeeping on the latter class, while it is highly essential that the former class be properly accounted for. You must, therefore, next divide your raw materials into two groups: one the Unclassified, of which you will keep a very simple record; the other the Classified, of which you will keep a record of materials ordered, on hand, reserved for manufacturing orders, and available. It is the latter group only which it is worth while to classify minutely and symbolize.

As an ounce of illustration is worth a pound of explanation, let us get busy on a real example of classification, taking first the raw materials in a printing plant. After listing all the materials in the place, we will leave out of consideration for the present those which are not kept in stores at all, such as the adding machine and the duplicating machine in the office. Of the classifiable remainder it is obvious that some of them can be used for many different purposes about the plant, while others have one use only. Some, like type metal, can be used only for composing-room products; others for press-room products or for job work. There may also be a collection of forms printed outside and therefore raw materials for this plant, which can be used only for special purposes.

You remember that in the base sheet which is the foundation of our whole mnemonic classification, S was reserved for stores. Let us fit in our printing plant materials under S as follows: [1]

SA	
SB	
SC	Special stores for composing-room products
SD	
SE	
SF	Forms, printed and ruled matter
SG	
SH	
SJ	Special stores for job work
SK	
SL	
SM	
SN	
SP	Special stores for press-room products
SQ	
SR	
SS	
ST	
SU	
SV	Classified stores used for a variety of purposes
SW	
SX	
SY	
SZ	

Type metal obviously comes under SC, and by all the rules will be known as SCM. Type metal, however, comes in different chemical compositions and from different firms. " Type metal " is a class rather than an individual thing. Our symbol must finally symbolize the individual, but as the number of individuals in a given class may and does in many cases exceed the number of letters in the alphabet, we will drop the mnemonic feature at this point and use numbers. Then the type metal purchased from the A Company will be SC1M, that from the B Company, SC2M, etc. The presence of the numeral before the last letter of the symbol always shows the man who is dealing with this classification that he is handling an individual item and not a class of things; and this is another good reason for departing from the mnemonic principle at this point.

The greater part of our stores, however, will fall in the SV class, which will be subdivided thus:

[1] In this and succeeding classifications in this article, a double column arrangement is used to save space. In practice this should never be done. A single column with all the letters allows room for the inevitable expansion.

SV-A
SV-B
SV-C
SV-D
SV-E
SV-F
SV-G
SV-H Hardware and other supplies used for maintaining plant and equipment, principally metal
SV-J
SV-K Inks and inking material
SV-L Liquids, semi-liquids and solids usually used in solution, inks and inking material excepted
SV-M Mineral products not elsewhere classified
SV-N
SV-P Papers, boards, etc.
SV-Q
SV-R
SV-S Office supplies not elsewhere classified
SV-T
SV-U
SV-V
SV-W
SV-X
SV-Y
SV-Z

Our inks will be subdivided like this:

SVKA
SVKB
SVKC Copying inks
SVKD
SVKE
SVKF
SVKG
SVKH
SVKJ
SVKK
SVKL Lamp blacks
SVKM
SVKN
SVKP Printing inks
SVKQ
SVKR
SVKS
SVKT Time-stamp ribbon
SVKU
SVKV
SVKW Writing fluids
SVKX
SVKY
SVKZ

Printing inks fall into the following groups:

SVKPA
SVKPB Black
SVKPC
SVKPD
SVKPE
SVKPF
SVKPG Green
SVKPH
SVKPJ
SVKPK
SVKPL
SVKPM
SVKPN Brown
SVKPP Pink
SVKPQ
SVKPR Red
SVKPS
SVKPT
SVKPU Blue
SVKPV Various inking materials (inkoleum and dryer)
SVKPW White
SVKPX
SVKPY Yellow
SVKPZ

Finally we get down to each particular brand of ink we will have:

SVKP 1 B	Regular Black	SVKP 5 B	Magazine Black
SVKP 2 B	Book Black	SVKP 6 B	Process Black
SVKP 3 B	Catalogue Black	SVKP 7 B	Tablet Black
SVKP 4 B	Form letter Black		

To introduce another wrinkle, let us classify the paper stock. Our base sheet for this will be as follows:

SV-PA		SV-PN	
SV-PB	Book papers	SV-PP	
SV-PC	Card stock, including tag board	SV-PQ	
		SV-PR	
SV-PD		SV-PS	
SV-PE		SV-PT	Tissue
SV-PF		SV-PU	
SV-PG	Blotting paper	SV-PV	Cover
SV-PH		SV-PW	Writing
SV-PJ		SV-PX	
SV-PK		SV-PY	
SV-PL	Lining paper	SV-PZ	Miscellaneous
SV-PM	Manila		

Book papers classify as follows:

SV-PBA		SV-PBN	English finish
SV-PBB		SV-PBP	
SV-PBC	Coated	SV-PBQ	
SV-PBD		SV-PBR	
SV-PBE		SV-PBS	Super calendered
SV-PBF		SV-PBT	Toned
SV-PBG		SV-PBU	Poster
SV-PBH	Hand made	SV-PBV	
SV-PBJ	Japan	SV-PBW	Wove
SV-PBK		SV-PBX	
SV-PBL	Laid	SV-PBY	
SV-PBM	Machine finish	SV-PBZ	Miscellaneous

We are now getting warm on the trail. If we want to classify an English finish paper, for instance, from the Princeton Paper Company, our symbol will be SV-PB1N. This paper, however, has dimensions and the dimensions may be the only distinguishing features between several items of this particular stock. This is what that hyphen is for after the V. Here you insert the dimensions and this item will be symbolized SV 44 48 60 PB1N which will mean English finish book paper made by the Princeton

SV-P Papers, Boards, etc.		SV-PB Book Papers		SV-PBN Book Papers, English Finish		Individual Product Group SV-PB1N English Finish Book Paper Princeton Paper Co.	
SV-PA		SV-PBA		→ SV-PB 1 N	*Princeton Paper Co.*	SV 24 36 60 PB1N	60 Pound, 24 × 36
SV-PB	*Book Papers* →	SV-PBB		SV-PB 2 N		SV 25 38 60 PB1N	60 Pound, 25 × 38
SV-PC	Card stock, including tag board	SV-PBC	Coated	SV-PB 3 N	Hardy & Estes	SV 28 42 80 PB1N	80 Pound, 28 × 42
		SV-PBD		SV-PB 4 N		SV 28 42 100 PB1N	100 Pound, 28 × 42
SV-PD		SV-PBE		SV-PB 5 N	Walker Mills Co.	SV 32 44 100 PB1N	100 Pound, 32 × 44
SV-PE		SV-PBF		SV-PB 6 N	Norway Paper Co.	SV 42 56 120 PB1N	120 Pound, 42 × 56
SV-PF		SV-PBG		SV-PB 7 N		SV 41 58 140 PB1N	140 Pound, 41 × 58
SV-PG	Blotting paper	SV-PBH	Hand made	SV-PB 8 N			
SV-PH		SV-PBJ	Japan	SV-PB 9 N			
SV-PJ		SV-PBK		SV-PB 10 N			
SV-PK		SV-PBL	Laid	SV-PB 11 N			
SV-PL	Lining Paper	SV-PBM	Machine finish	SV-PB 12 N			
SV-PM	Manila →	SV-PBN	*English Finish* →	SV-PB 13 N			
SV-PN		SV-PBP					
SV-PP		SV-PBQ					
SV-PQ		SV-PBR					
SV-PR		SV-PBS	Super calendered				
SV-PS		SV-PBT	Toned				
SV-PT	Tissue	SV-PBU	Poster				
SV-PU		SV-PBV					
SV-PV	Cover	SV-PBW	Wove				
SV-PW	Writing	SV-PBX					
SV-PX		SV-PBY					
SV-PY		SV-PBZ	Miscellaneous				
SV-PZ	Miscellaneous						

Paper Company, size 44×48, weight 60 pounds to the ream, and the symbol will tell the cost clerk and the storekeeper that this is an item of classified stores used in the press department for various purposes.

Some keen-eyed searcher for the logic of this matter has undoubtedly observed that the classification of book papers is not (as he would say) properly coördinated. All book papers are either laid, wove, or coated, and therefore the other varieties should be classified under SV–PBC coated, SV–PBL laid, or SV–PBW wove. Machine finish, for instance, which is a variety of wove paper, would be SV–PBWM, if this arrangement were logically accurate. But to do this means making the symbol one letter longer, whereas a practical classification such as the one proposed is briefer, just as mnemonic, and just as definite and accurate. In such instances as this, logic may safely be sacrificed to expediency.

Perhaps it is worth while to illustrate this method in another department of work: to wit, a machine shop. In order not to betray anybody's trade secrets, suppose we take a classification of stores for the machine shop in a technical training school. The base sheet reads like this:

SA	Stores used for various purposes not elsewhere classified	SM	
SB		SN	Castings for engines
SC	Castings for chipping exercises	SP	
SD		SR	
SE	Special classification for exercises not elsewhere classified	ST	
SF	Castings for face plates	SU	
SG		SV	Stores for a variety of purposes
SH		SW	
SJ		SX	
SK		SY	
SL	Castings used for lathes	SZ	Stores for constructing clamping or fastening devices

The only item coming under SA is S–AD, drip pans. S–AD is subdivided thus:

S–A1D	Drip pans rectangular
S 23½ × 6 × 1½ A1D	Rectangular drip pans 23½″ × 6″ × 1½″.
S 2½ × 6 × 5½ A1D	Rectangular drip pans 2½″ × 6″ × 5½″.

Class Letter	General Classification	Molding Machines M		Plain Power Ramming Machines MR		Base Group P.P. Ramming Machines MRB		Strain Bar Division Base Group MRBB		R. H. Strain Bars MRB1B Factory Order Number Added	
A	Auxiliary	MA	Automatic Stripping	MRA		MRBA		MRB1B	*Right Hand*	MRB1B 68	Right Hand
B	Business (Administrative)		Plate Machines			MRBB	*Strain Bar*		*Strain Bars* →		Strain Bars,
C	Selling	MB		MRB	*Base Group* →		*Division* →				68th Lot
D	*Mfg.* Departments	MC	Core Ramming Machines	MRC				MRB2B	Left Hand Strain		Manu-
E	Erecting	MD		MRD		MRBC	Cylinder		Bars		factured
F		ME		MRE			Division	MRB3B	Trunnions		
G	Grinders	MF		MRF		MRBD		MRB4B	Trunnion Shafts		
H		MG		MRG		MRBE					
J		MH	Hinged Vibrator Ma-	MRH	Hose Group	MRBF					
K	Milling Cutters		chines, Hand Ramming,			MRBG					
L			Hand Draft	MRJ		MRBH					
M	*Molding Machines* →	MJ	Jarring Machines	MRK		MRBJ					
N		MK		MRL		MRBK					
P		ML		MRM	Miscellaneous	MRBL					
R		MM			Group	MRBM	Miscellaneous				
S	Stores, Raw Materials	MN		MRN			Division				
T	Tools	MP	Power Ramming,	MRP		MRBN					
U			Power Draft Machines			MRBP	Platen Division				
V		→ MR	*Plain Power*	MRR		MRBR					
W			*Ramming Machines* →			MRBS					
X	Part Construction			MRS		MRBT					
Y	Machinery, Motive Power	MS	Shockless Jarring Machines	MRT		MRBU					
Z	Land and Buildings	MT		MRU		MRBV					
		MU		MRV		MRBW					
		MV		MRW		MRBX					
		MW		MRX		MRBY					
		MX		MRY	Yoke Group	MRBZ					
		MY		MRZ							
		MZ									

You will observe that 1 is used for rectangular drip pans, although this place has pans of no other shape. This is to preserve the principle of always having a numeral before the last mnemonic letter. You will also observe that the dimensions are here inserted immediately after the S. This is due to the fact that the dimensions cannot be placed anywhere else in so short a symbol without conflicting with the numeral which indicates the individual.

Here as elsewhere the SV classification is the largest and most important.

The SV base sheet follows:

SV–A	Stores not elsewhere classified	SV–M	Metals and their alloys not elsewhere classified
SV–B	Brass and products of brass not otherwise classified	SV–N	
SV–C	Iron castings and products of iron not elsewhere classified	SV–P	
SV–D		SV–R	
SV–E		SV–S	Steel and products made of same not elsewhere classified
SV–F		SV–T	Tools and implements not elsewhere classified
SV–G		SV–U	
SV–H		SV–V	
SV–J	Belting, hangers, pulleys, and transmission devices not elsewhere classified	SV–W	
SV–K		SV–X	
SV–L	Lubricants and liquids not elsewhere classified	SV–Y	
		SV–Z	

Note that SV–T, Tools and implements not elsewhere classified, refers to the tools while still in stores, and not to those in the tool room. The subject of tool classification is, as Kipling would say, another story. It is probably unnecessary to illustrate further the method of constructing a classification for raw materials.

V

Keeping Tab on Finished Parts; How Mnemonic Classification of Products Saves Time and Prevents Error in Factory and Office

In the last section on stores classification, you remember, I pointed out the advantages to be gained from the standardization which always accompanies the mere effort to classify materials. This benefit comes not only to stores system, but to the cost system, filing system, and other departments of the business when classification is undertaken in those departments. The classification even of parts in process has the same result and has led to the modification and improvement of design in machines. For instance, a large concern, manufacturing vehicles of all sorts, found, when it began to classify parts, that it had slightly different sized hubs on almost every wheel made — some two hundred and thirty varieties. The most obvious thing to do was, of course, to reduce this enormous variety, which was brought down finally to twenty-two. The economies from this change are easy for any practical man to calculate.

The classification of stores, as was seen, is an easy and simple matter, which can be done by almost any one who can tell a B from a buzzsaw. If you start with your definitions right, remembering that stores are raw materials — that is, have had no work done on them in your plant, while worked materials are all parts which have had some labor expended on them by you, including finished parts or stock — the rest is easy.

The classification of worked materials, however, is not quite so simple as that of stores, for it must be based upon a strictly logical analysis of the product being made and this analysis can be made only by one thoroughly familiar with the product and the details of its design and construction. Inasmuch as the classification should be made only of those parts which at any stage of the process may be treated as units, it is necessary for the classifier to know what these units are. Since, further, the classification must be so made that it automatically reduces down to the finished product as the parts become assembled, the relation of one part to another and to the whole must be clearly understood.

This information should be gathered from the drawings and bills of materials for the product. The bill of materials shows the entire list of raw materials and partly finished parts going into the machine, together with the dimensions and quantity of each. The drawing shows the shape and dimensions of each part of the finished product and the method of bringing these parts together.

A very complex product, such as a machine, consists first of several large groups of parts. Take, for example, a molding machine, such as is found in up-to-date foundries. This machine consists of four groups, any one of which may be assembled independently and put into worked materials stores if necessary.

These are the base group, the hose group, the yoke group and the miscellaneous group, the latter consisting mainly of those parts which are necessary for the assembling of the other three groups into the completed machine. Again, each of these groups is made up of divisions which may be made independently: the base group, for example, consists of a strain bar division, a cylinder division, a platen division and, again, a miscellaneous division. These divisions likewise consist of sections, subsections, elements, and so on, until you get down to the separate pieces which go into the machine.

In the original base sheet which ties together all classifications into the cost classification, the letters F to W, with the exceptions of S and T, were reserved for products. Suppose that you take M for molding machines. Molding machines are of several varieties of which the following are a few examples:

MA	Automatic Stripping Plate Machines	MN	
MB		MP	Power Ramming, Power Draft Machines
MC	Core Ramming Machines	MR	Plain Power Ramming Machines
MD		MS	Shockless Jarring Machines
ME		MT	
MF		MU	
MG		MV	
MH	Hinged Vibrator Machines, Hand Ramming, Hand Draft	MW	
MJ	Jarring Machines	MX	
MK		MY	
ML		MZ	
MM			

We are dealing with a plain power ramming machine, MR. Classifying the groups composing this machine we get:

MRA	MRN
MRB Base Group	MRP
MRC	MRR
MRD	MRS
MRE	MRT
MRF	MRU
MRG	MRV
MRH Hose Group	MRW
MRJ	MRX
MRK	MRY Yoke group
MRL	MRZ
MRM Miscellaneous group	

The base group divides into:

MRBA	MRBN
MRBB Strain bar division	MRBP Platen division
MRBC Cylinder division	MRBR
MRBD	MRBS
MRBE	MRBT
MRBF	MRBU
MRBG	MRBV
MRBH	MRBW
MRBJ	MRBX
MRBK	MRBY
MRBL	MRBZ
MRBM Miscellaneous division	

And the strain bar division again resolves itself into the final units or elements as follows:

MRB1B	Right hand strain bars	MRB3B	Trunnions
MRB2B	Left hand strain bars	MRB4B	Trunnion shafts

It frequently happens, as in the case of these molding machines, that several different sizes of the same design are manufactured. The symbols for all these sizes and their parts are exactly alike, except that some significant dimension peculiar to each size is selected and inserted after the first letter of the symbol.

The particular right hand strain bar we have in mind may be for a machine with a platen 10 × 32 inches; and our symbol for that piece of metal then will be M 10 32 RB1B. If this strain bar were for a machine with a platen 16 × 48 inches, its symbol would be M 16 48 RB1B.

Notice how these symbols develop into the symbol for the complete machine. We start manufacturing on M 10 32 RB1B, the right hand strain bars; M 10 32 RB2B the left hand strain bars. When these are made and assembled into the strain bar division, they become M10 32 RBB. In the meantime the cylinder division, M 10 32 RBC, and the platen division, M 10 32 RBP, have been made in another part of the shop. These, together with the miscellaneous division M 10 32 RBM, are brought together to be assembled into the base group of this machine. When this is done, B for strain bar division, C for cylinder division, M for miscellaneous division, and P for platen division, drop out of the symbol and we have the symbol M 10 32 RB as the symbol for the base group. While this is going on, the hose group, M 10 32 RH, and the yoke group, M 10 32 RY, have been made up and assembled and these, together with the miscellaneous group, go to the final assembling, from which emerges the completed machine, M 10 32 R, which means a plain power ramming machine with a platen 10 × 32 inches.

Obviously, the same set of drawings, route charts, progress sheets, and so forth, may be used for this machine over and over again. It is important, however, that we keep track of different lots going through. It happens that this particular machine is sent through in lots of fifty and each lot is numbered serially. The last lot is, perhaps, No. 68. This is indicated by adding the lot number at the end of the symbol.

If we want to symbolize all the operations on this machine all we have to do is to prefix a number to the symbol of the piece, division or group on which the work is to be done. Thus the first operation on the right hand strain bar may be to lay out, the second operation to drill. We indicate this simply as 1 M 10 32 RB1B 68; 2 M 10 32 RB1B 68. Every piece of material used in this machine and every bit of labor that goes into it, if consistently symbolized, is charged at once by the cost clerk to this sixty-eighth lot of M 10 32 R. Progress sheets are easily kept from operation tickets, which contain the symbol for the operation and the piece worked on; and the stage of development of any job in the plant is easily determined at any time. Each piece and each operation is positively and accurately identified without the possibility of confusion with any other piece or any other operation. Instructions, orders, and accounts require less writing, and are easily checked because an inconsistency or a mistake in the symbol sticks out like a sore thumb.

If, for example, you saw a symbol 2 M 10 3 RB1B 68, you would know that something is wrong, because there is no power ramming machine with a platen 10 × 3. Or if you saw a symbol 1 H 10 32 RB1B 68, you would know that something is wrong with that, because there is no machine manufactured by this Company with an H as the first letter of the symbol. On the other hand, if the machine or part were merely numbered as is the usual practice, a part whose real number is 273648 might by the copyist's error be called 276348, and there is nothing in that symbol to show any one that a mistake has been made. Such an error can be discovered only when the part is brought out and shown to be the wrong one.

Symbols developed in this way for stores and worked materials are self-expanding and self-indexing. It is evident that, once your base sheets either of stores or of worked materials are properly made, it is merely a matter of logical deduction to fit any article into its appropriate place. In the case of stores this is done by a clerk. In the case of worked materials on a complicated machine, it must be done by one familiar with the product.

After the symbols are made they are arranged alphabetically like the words in a dictionary; and the symbol for any article, or conversely the name of the article corresponding to any symbol, is found as easily as you find your name in the directory. If you start with the symbol you find the corresponding name of the part exactly as you find the definition of a word in the dictionary. If you start with the name of a part and want the symbol you have an approximate idea of its place in the machine and then follow down through group, division, section, until you find the unit you are looking for.

It is evident that the use of these symbols for stores, worked materials, and finished stock is manifold. In the first place, they identify the items and, as there is but one symbol to one

Class Letter		C · Construction		CR Real estate		CRC Construction of new buildings		CRCN Interior appointments		CRCNL Lighting		CRCNLL Oil	
A		CA		CRA		CRCA		CRCNA		CRCNLA		CRCNL 1 L	D & S oil for
B		CB		CRB		CRCB		CRCNB		CRCNLB			lanterns
C	*Construction*	CC	Circuits, loops,	CRC	*Construction of*	CRCC	Contracts	CRCNC		CRCNLC		CRCNL 2 L	D & S gasoline
D			phantoms, and		*new buildings*			CRCND		CRCNLD			for flambeaux
E	Equipment		so on	CRD		CRDC		CRCNE		CRCNLE	Electric	CRCNL 3 L	
F	Finance and	CD		CRE		CRCE		CRCNF	Furnishing		wiring	CRCNL 4 L	
	accounts	CE		CRF		CRCF		CRCNG		CRCNLF			
G	General	CF		CRG		CRCG		CRCNH	Heating	CRCNLG	Gas fixtures		
H		CG		CRH		CRCH			plant	CRCNLH			
J		CH		CRJ		CRCJ		CRCNJ		CRCNLJ			
K		CJ		CRK		CRCK		CRCNK		CRCNLK			
L		CK	Cables	CRL		CRCL		CRCNL	*Lighting*	CRCNLL	*Oil*		
M		CL	Pole lines	CRM	Maintenance of	CRCM		CRCNM		CRCNLM			
N		CM			real estate	CRCN	*Interior*	CRCNN		CRCNLN			
P	Operation	CN	Conduits	CRN			*appointments*	CRCNP		CRCNLP			
R	Rates	CP	Poles, wires,	CRP	Purchase of	CRCP	Plans and	CRCNR		CRCNLR			
S			and so on		property		specifications	CRCNS		CRCNLS			
T			*Real estate*	CRR		CRCR		CRCNT		CRCNLT			
U		CR		CRS		CRCS		CRCNU		CRCNLU			
V		CS		CRT		CRCT		CRCNV		CRCNLV			
W		CT		CRU		CRCU		CRCNW		CRCNLW			
X	Executive	CU		CRV		CRCV		CRCNX		CRCNLX			
Y		CV	Private lines,	CRW		CRCW		CRCNY		CRCNLY			
Z			wire, and so on	CRX		CRCX		CRCNZ		CRCNLZ			
		CW		CRY		CRCY							
		CX		CRZ		CRCZ							
		CY											
		CZ											

item, they eliminate the possibility of mistake and accidental substitution of one article for another. In the second place, they make it possible for the cost department to trace accurately each item of labor and material expenditure, since the production ticket on which the work is done or the requisition on which materials were issued has the symbol of the product on it. In the third place, the worked materials symbols provide a basis for routing the work through the shop and, if properly made, they show the superintendent what parts of the product can be started independently and in what order parts can be assembled. In the fourth place, by reducing the amount of writing required, they make possible the transmission of all orders in writing and the consequent fixing of responsibility. Of other advantages not the least is the by-product pointed out several times in these articles: the standardization of materials and of methods which, in practice, invariably accompanies the mere effort to classify and symbolize.

VI

Right Filing and Easy Finding; How a Logical Mnemonic Classification Expedites the Handling of Records and Correspondence

The young lady file clerk happened to remark inadvertently: "This is my twenty-sixth birthday." Suddenly recovering herself she said: "For conscience's sake, don't let that get out." An unfeeling official of the company who was passing through the file room just then suggested: "Don't worry; just put that information in the files and it will never see the light of day again."

This official knew from the depths of bitter experience how easy it is to file things and how extremely difficult to find them after they are filed. A filing system often illustrates the proposition that a thing may be lost though you know where it is, as the traveler observed when his watch slipped overboard into the Atlantic.

The experience of this particular concern is typical and worth narrating. In the expectation of handling a great deal of correspondence, they started out fully impressed with the importance of having this correspondence easily accessible. They engaged a promising-looking young man, one of those thin-faced blonds with broad forehead and pointed chin and bright blue eyes behind a pair of spectacles, who gave the impression of keen intellectual alertness and analytic power. The material to be handled consisted of all the usual correspondence of current interest and, in addition, a large amount of correspondence of permanent interest which had to be made easily accessible. It was also necessary to provide for the filing of large quantities of data on a wide variety of subjects. The young man was told to devise a system to take care of this.

Being fully imbued with the American spirit of independence and initiative, he decided to make a classification of knowledge, at least so much of it as was involved in this particular business, on his own original lines. The classification naturally included a great deal that the young man knew and a great deal more that he did not. It ranged all the way from the design of paper clips, through the sanitary properties of lace curtains, to the comparative merits of the American and the British constitutions, with an annex for the mysteries of theology. Every item was numbered, a set of vertical files purchased and equipped with folders numbered serially. Every letter and bit of information filed was to have a number attached to it indicating its subject matter and put in the folder under that number, and all correspondence was then to be cross-indexed by name.

This was the system that was turned over to the young lady file clerk. After spending several weeks trying to get the hang of the classification, she started in to put away the enormous mass of literature that had accumulated while she was studying the system. It took her about one day to discover that most items could just as well be classified under four or five heads, and that almost every piece of paper she handled had to be classified under two or more. She also found it easier in most cases to start a new subject and give it a new number than to hunt through the classification and find the one already assigned. And when it came to cross-indexing, she also used her initiative with reference to whether she would index by the name of the individual or the name of the firm, and was quite impartial.

The result of this "system" may easily be imagined. The writer of this article was one of the officials who suffered by it; and the only way out that I could find (under all the circumstances) was to run a separate filing system of my own in charge of my secretary. This meant that every letter I wrote had to have two carbons: one for myself and the other for the official file; and that every letter that came in to me was kept in my own office, instead of in the general file.

After this condition had existed for three or four months, an organization that makes a business of filing systems was invited to come in and straighten it out. They installed a different type of filing cabinet, put a different kind of tab on the folder, arranged a perfect rainbow of colors in the card-index cross-references (all of which they carried in stock at reasonable prices), and left a neatly printed and bound set of instructions. This complication was grafted on at once, and our latter state was worse than our first. By this time the other executives had all been forced to start their own filing systems, and so it continued until the firm went out of business — each executive a king in his own office, and the central files a cemetery.

A good filing system has more than a sentimental value. Along comes a hurry-up order for an estimate on a special machine. You remember making one of these three years ago. At that time it took three weeks to prepare your estimate. You can save that three weeks' delay now if you can find the former estimate; and if you cannot find it, you either lose the order or make a wild guess, on which you will probably lose money. A filing department which provides for the speedy recovery of any document put away in it has an immediate cash value.

You are perhaps a member of a professional society which asks you to prepare for their next meeting a paper on the tensile strength of various grades of yarn. You have been experimenting on this for many years and your data are filed away somewhere. Realizing the compliment implied in their request for your information, you feel under obligation to make your report as complete and exact as possible. It is worth a great deal to your professional reputation to have a filing system which is certain to contain all the records you have made on this subject.

Or it may be that you are in charge of an office that has very large quantities of incoming mail; you are perhaps maintaining a force of fifteen file clerks who receive twelve dollars a week. If one way of filing your mail takes one-half the time that your present method consumes, the improved method is worth about ninety dollars a week to you.

The President's Commission on Economy and Efficiency points out that "the departments in Washington receive annually 43,000,000 communications and dispatch during a like period 22,000,000, making a total of 65,000,000 communications handled each year." Twenty-five million of these are filed at a cost of $260,000. It is interesting to note in this connection that the cost per thousand for filing varies between $6.53 in the Post Office Department and $20.33 in the Department of the Interior, the latter being 300 per cent more than the former.

According to the Commission, the essential requirements of a filing system are the following:

"(*a*) Certainty of obtaining a particular paper or of obtaining all the papers relating to a particular subject; and this certainty to be independent of the time that has elapsed since the filing of the paper.

"(*b*) Rapidity of obtaining a particular paper or of obtaining all papers relating to a particular subject; and this rapidity to be only slightly affected by the time which has elapsed since filing.

"(*c*) Rapidity with which documents may be filed.

"(*d*) Cheapness of operating the system.

"(*e*) Simplicity.

"(*f*) Reduction to a minimum of the space required for documents.

"(*g*) Miscellaneous minor requirements and desirable features, such as cross-references, numbering, and so on."

To meet these requirements, it is necessary that every paper for which it is reasonably certain there will be a demand shall be filed; that all papers on a given subject shall always be filed in the same place and so indexed that they can readily be found;

that the basis for indexing shall be such that the proper identification mark can quickly be placed on each paper preparatory to filing; that the files be so arranged and indexed that the proper place for each paper can be readily found; that the system be simple enough for an average ten-dollar or twelve-dollar clerk to handle; that such cross-references be maintained as are really necessary, and no others.

The one absolutely indispensable prerequisite to an efficient filing system is a logical and complete classification of the material to be handled. This classification is the basis of the symbol — be it a number, a letter, a sign, or a combination of these — which is placed upon each paper and is the guide to be followed in filing and in finding it. Unless this classification groups the entire subject matter handled by the concern in a manner so logical that all intelligent people can easily use it in the same way, and unless further it provides a place for each and every subject on which the concern may require information, the filing system is sure to fail. The first thing to do then in the filing department as elsewhere in the business, is to make such a classification and to adopt a system of symbols by which its use may be facilitated.

The Commission on Economy and Efficiency recommends for this purpose the Dewey decimal classification, designed to cover "all knowledge." This classification was described and criticized in section II of this series. In addition to what was said there, it may be remarked at this point that very few concerns are practically interested in a classification which covers all knowledge. There are of course individuals in most concerns who carry all knowledge in their heads but, as a rule, the responsible officials are not deeply interested in that fact. Each office has its own limited field; and the most that the Dewey system can do in such a field is to suggest a mode of classification and of numbering the items. The Commission on Economy and Efficiency illustrates this by an application to a telephone company, as follows:

000	General	400	Equipment
100	Executive	500	Operation
200	Finance and accounts	600	Rates
300	Construction		

Each of the above general classes is susceptible of further subdivision by the employment of additional digits. For example, the heading "300: Construction" is subdivided as follows:

300 *Construction*	340 Conduits
310 Real Estate	350 Poles, wires, etc.
320 Pole lines	360 Cables
330 Circuits, loops, phantoms, etc.	370 Private lines, wire, etc.

310: Real Estate is subdivided thus:

310 *Real Estate*	310.2 Construction of new buildings
310.1 Purchase of property	310.3 Maintenance of real estate

310.2: Construction is subdivided as follows:

310.2 *Construction of new buildings*	310.22 Contracts for new buildings
310.21 Plans and specifications	310.23 Interior appointments

310.23: Interior Appointments has these subdivisions:

310.23 *Interior appointments*	310.232 Heating plant
310.231 Furnishing	310.233 Lighting

310.233: Lighting is subdivided into:

310.233 *Lighting*	310.233.2 Gas fixtures
310.233.1 Electric wiring	310.233.3 Oil

The method of the Dewey system is in the main correct: to wit, to enumerate, first, all the kinds of information to be classified; second, to group these items into a limited number of classes; third, to give each of these classes a definite and unchanging symbol; fourth, to expand the classification under each group and symbolize each subdivision by an addition to the symbol for the group; fifth, to file all correspondence, data, and so on, numerically or alphabetically in accordance with the symbol.

The two advantages that the mnemonic system of classification and symbolization has over the Dewey system are: first, that the twenty-three letters of the alphabet used in the mnemonic system give the opportunity for a more rational classification than the ten possible groups of the decimal system; second, that a symbol consisting of letters may be made more easily mnemonic, *i. e.*, each letter being as a rule the initial of the term symbolized, recalls that term to mind more easily than a number arbitrarily chosen for that purpose. There is nothing about the expression "310.233.3" to suggest "Oil," as a subdivision of "Lighting" under " Interior Appointments " included in the " Construction of new buildings " under the heading of " Real estate " as a subdivision of " Construction," unless you have beaten the meaning of these numerals into your head by main force. In the preface to the seventh edition of *Decimal Classification*, Mr. Dewey says that " 016.581.974.742 readily translates itself to users of the system into ' Bibliography of the Flora of Albany Co., N.Y.' "

Without going behind the classification for the correspondence of the telephone company given by the Commission, suppose we symbolize it on a mnemonic basis. Our base sheet will be this:

A		N	
B		P	Operation
C	Construction	R	Rates
D		S	
E	Equipment	T	
F	Finance & accounts	U	
G	General	V	
H		W	
J		X	Executive
K		Y	
L		Z	
M			

C: Construction will be subdivided like this:

CA		CN	Conduits
CB		CP	Poles, wires, etc.
CC	Circuits, loops, phantoms, etc.	CR	Real estate
CD		CS	
CE		CT	
CF		CU	
CG		CV	Private lines, wire, etc.
CH		CW	
CJ		CX	
CK	Cables	CY	
CL	Pole lines	CZ	
CM			

CR: Real estate will be taken care of under the following headings:

CRA		CRF
CRB		CRG
CRC	Construction of new buildings	CRH
		CRJ
CRD		CRK
CRE		CRL

CRM Maintenance of real estate	CRU
CRN	CRV
CRP Purchase of property	CRW
CRR	CRX
CRS	CRY
CRT	CRZ

Construction of new buildings will involve the following operations:

CRCA	CRCN Interior appointments
CRCB	CRCP Plans and specifications
CRCC Contracts	CRCR
CRCD	CRCS
CRCE	CRCT
CRCF	CRCU
CRCG	CRCV
CRCH	CRCW
CRCJ	CRCX
CRCK	CRCY
CRCL	CRCZ
CRCM	

Interior appointments are thus subdivided:

CRCNA	CRCNN
CRCNB	CRCNP
CRCNC	CRCNR
CRCND	CRCNS
CRCNE	CRCNT
CRCNF Furnishing	CRCNU
CRCNG	CRCNV
CRCNH Heating plant	CRCNW
CRCNJ	CRCNX
CRCNK	CRCNY
CRCNL Lighting	CRCNZ
CRCNM	

Classification of lighting is further carried out as follows:

CRCNLA	CRCNLN
CRCNLB	CRCNLP
CRCNLC	CRCNLR
CRCNLD	CRCNLS
CRCNLE Electric wiring	CRCNLT
CRCNLF	CRCNLU
CRCNLG Gas fixtures	CRCNLV
CRCNLH	CRCNLW
CRCNLJ	CRCNLX
CRCNLK	CRCNLY
CRCNLL Oil	CRCNLZ
CRCNLM	

If two or three kinds of oil are used, they will be designated as CRCNL1L, CRCNL2L, etc., as already explained. I think it may fairly be claimed that this symbol is at least more intelligible than "310.233.3," and it has the further advantage of automatically checking itself. If, for instance, some one ordered oil and gave the symbol CRPNL2L, the purchase agent would know at once that there was something the matter with it because "P" in that particular location refers to the purchase of real estate and could not possibly mean "Construction of new buildings." But, if the order came for 310.133.3, the "1" might stand for "construction" as well as for "purchasing," and nobody offhand would know the difference without consulting the key to the classification.

The classification given by the Commission is used here simply as an illustration and not as an example of a good classification. If it were to be used for correspondence alone, it might do; but if, as was pointed out in section I, one classification can be made to do service for purchasing, costs, operation, filing, selling, and any other functions deemed advisable to perform, such a classification is in the end simpler and more economical.

Suppose, for example, we are running a store and we want to file copies of dodgers we have sent out advertising special sales. If we have to symbolize these dodgers for filing purposes, we may as well, if possible, use the same symbol for the dodgers as an expense item and for instructions and orders as to their preparation. If we are following the method described in these articles, we will first analyze the functions of a store and, in most cases, advertising will be one of our main headings. From the cost accounting point of view, advertising is obviously not a direct expense. It is merely an aid to the sale of merchandise. It is therefore an auxiliary expense and will fall under the broad group A in the cost classification. We will also use A specifically for advertising, and then we can get up a cost sheet like this:

AA — *Advertising*

AAA	Salaries and wages, except window-dressers	AAN	Newspapers
AAB	Billboards	AAP	Programs
AAC	Contributions	AAR	Reclamation of errors
AAD	Dodgers	AAS	Supplies and stationery, except for window-dressing
AAE		AAT	
AAF		AAU	
AAG	Catalogues '	AAV	Advertising mediums not elsewhere classified
AAH		AAW	Window-dressing
AAJ		AAX	
AAK		AAY	
AAL	Circular letters	AAZ	
AAM	Magazines		

Obviously we will symbolize dodgers AAD, and we will file them in the folder under that symbol. If our files are alphabetically arranged as they should be, all advertising matter will be together under AA. We can have there not only our own advertisements, but similar advertisements we have gathered in other places as suggestions. We can have in the same place a record of the cost of each type of advertising and we can have there records of all instructions and orders issued at any time for the preparation of dodgers. We can keep these all in the same file if we like; or, as will in most cases be preferable, we can have separate files for costs, for instructions, and for samples; but all symbolized in the same way.

Of course the minuteness of the subdivision will vary with the size and demands of the business. For a small concern, a few groups will be sufficient, and it is always possible, by the method here described, to subdivide a group at any time when it gets to the point of unwieldiness. It is often advisable also to use temporary groupings. If you are engaged in construction work you will want all the correspondence and data on a live job together under the job number where it is easily accessible. When a job is finished, you will dispose of a good deal of the papers in your files, and what is left of permanent value may be re-filed with safety under the general subject classification.

Again, for the purposes of an advertising campaign in a certain section of the country, you may want to group geographically all the data bearing on that section until the campaign is over. Whenever such a reclassification is made, a note must invariably be left in the files from which papers are taken indicating the new classification to which these have been removed and in which, of course, they are to be found.

If it is found desirable to carry the classification to great minuteness, it will often be necessary to classify letters and other papers under several heads. The usual way is to file the document under its most important heading and put a note under the other headings referring to the place where it is filed. It is sometimes better to brief other headings and file them where they belong. Where the files are constantly used, the latter method in the long run saves time. Letters sent from your office should deal with but one subject at a time. If they cover several subjects, separate letters should be written for each and filed accordingly. This is also in many cases a time and money saver and a strong preventive of error.

Most concerns using this system find cross-indexes in the card form unnecessary. One is not usually interested in finding a letter from a particular person except on account of the subject matter of the letter; and if the subject matter is known, it can be found without reference to the name of the writer. If, however, it is desirable to keep track of the name, this can easily be done with a simple card index, care being taken to index each paper under the name both of the writer and of the firm, as one or the other is easily (and usually) forgotten after the lapse of a few months.

Every paper should have stamped on it a blank in which the mail clerk or other responsible individual may write the symbol under which it is to be filed. In case of incoming mail, the symbol should be attached when the mail is opened. In case of outgoing mail, it should be attached by the dictator. As a rule, the symbols for all other papers should be affixed by the file clerk. When the proper classification cannot be determined by the file clerk, the people with whom the papers originated should be consulted.

This system of filing is of course not limited to correspondence and technical data. It can and should be used for filing all cost data, purchase orders, contracts, proposals, reports, price lists, estimates, catalogues, books and periodicals, blue-prints, tracings, photographs, maps — in short, anything and everything of which permanent record is to be kept, and which should be easily and quickly accessible when called for.

The original classification should be made so as to cover everything intended to be kept in the files. If something comes in later or was inadvertently omitted, there are always a few letters left under which to include the new items. When properly done, the classification and index is elastic, self-expanding, and unlimited in its scope; and when it is applied to every record handled in connection with the business, its significance soon becomes known to every one concerned, and the ability to use it quickly and accurately grows rapidly into an individual and an organization habit.

ELEMENTARY TIME STUDY AS A PART OF THE TAYLOR SYSTEM OF SCIENTIFIC MANAGEMENT

AN EXPOSITION OF THE PRINCIPLES AND METHODS OF THE ART WHICH IS THE FOUNDATION OF SCIENTIFIC MANAGEMENT

By H. K. HATHAWAY

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ELEMENTARY time study is in many respects the most interesting phase of scientific management, and plays a most important part in the application of the principles upon which the science of management is based, as well as in the development of the science itself. Indeed, it would be almost as difficult for the science of chemistry to exist if there were no such thing as quantitative analysis, as for scientific management to exist without elementary time study.

In 1893 Frederick W. Taylor, in a paper describing his differential piece work system, developed at the Midvale Steel Works, called attention to the method originated by him for arriving at the time required to perform any given piece of work, namely, the study of unit times, or what is now generally known as elementary time study. He stated, however, in his paper on Shop Management, several years later, that he was disappointed in the interest aroused being chiefly in the piece work system rather than in the substitution of a fair and accurate method for setting rates in place of the guess-work methods generally in vogue. This, however, was but natural, as at that time ordinary or straight " piece work " was well known as a means of increasing output; and Mr. Taylor's differential rate, offering as it did not only the incentive of a reward for greater production, but the added feature of a more severe penalty in case of failure, appealed to managers generally as a good thing; while elementary time study being something entirely new and beyond their ken, as well as calling for considerable work, was shied away from; especially as every foreman and many superintendents and managers felt that, either by reason of their experience, or through some supernaturally endowed intuition, they were able to tell at a glance how long any job should take.

Indeed, the writer can look back, a few years to the time when he became a foreman and recollect that, by virtue of several years' experience, he had considerable confidence in his own ability to shut one eye, go into a trance, and fix the proper time for a job.

Another popular method for setting piece rates — on repetition work especially — has been to put a good man on the job; keep a record for several days of his production; divide the time by two or three; and arbitrarily make the result the rate. Many other methods, equally bad, have from time to time been adopted in piece work shops, all of them being based on ignorance and deceit, and lacking a spirit of fairness and mutual confidence between the employer and employee.

Where piece rates are set by any of the old methods, the management feels little or no responsibility for the provision and maintenance of proper facilities and good working conditions; such as make it possible for the worker to perform, without undue exertion or worry, a relatively large day's work; and as a result, instead of true coöperation we see the management on one hand putting a task up to the worker that is either ridiculously easy, or on the other hand impossible or extremely difficult; without, in many of the latter cases, knowing how he is to accomplish it, and making little or no effort to help him solve the problem. Ultimately, even where the task is unreasonably hard, the workman, by the exercise of ingenuity and perseverance, may bring about conditions that enable him to first accomplish the task, and gradually to exceed it, until, unless he adopts the expedient of systematically loafing as a means of self-protection, his earnings become, in the eyes of his employers, excessive. He is then rewarded by having the piece rate arbitrarily cut to a point where he has difficulty again in earning a fair day's pay.

Improper piece rate setting, or, to put it in another way, ignorance of their own business on the part of the management, and a disregard of their responsibility for the maintenance of proper working conditions, has been, and still is, one of the chief causes of distrust and antagonism between employer and employee. In this connection it may be well to point out that while the employer has been quick to see the iniquity of "soldiering" on the part of the workman, he is inclined to overlook the fact that at least half the responsibility for its existence lies at his own door.

While this article is intended to treat of but one element of Scientific Management, it is of the utmost importance that we do not lose sight of its relation to the subject as a whole; and while not minimizing its individual importance, the writer wishes to emphasize the fact that it is, after all, but one part of the management machine. Take it away, and the machine runs imperfectly; and alone it is practically useless.

It will be wise, even at the risk of covering ground gone over before, to show just where the part of Scientific Management fits in. Mr. Taylor states the four basic principles in his book *The Principles of Scientific Management*, in such a concise manner that it is not until he has studied the subject exhaustively and become quite familiar with it through intimate contact that the average person grasps their full meaning and importance. These basic principles are as follows:

1. The development of a science in place of "rule-of-thumb" knowledge. This means scientific investigation and study; the collection and codification of data and their reduction to laws. In this "time study" plays an obviously important part.

2. The scientific selection and training of the workman in place of workmen being employed as a result of expediency, necessity, or mistaken personal preference on work for which they may be physically, temperamentally, or mentally unsuited; or, as Mr. Taylor expresses it, "in the past he (the workman) chose his own work, and trained himself as best he could." Improper selection of the workman has resulted in many "square pegs in round holes."

3. Hearty coöperation between the management and the men, so as to insure all work being done in accordance with the principles of the science which has been developed.

4. An almost equal division of the work and responsibility for results between the management and the workmen, the management taking over all of the work for which they are better fitted than the workmen; in the past almost all of the work, and the greater part of the responsibility were thrown upon the men.

If these principles are kept in mind, it will be seen that time study is only a means to their proper application, and that it must not be considered apart from its relation to Scientific Management as a whole.

Misunderstanding of the purpose of time study is common alike to management and workmen, the management on one hand thinking that their task and responsibility end when they have found how long it takes to do things, and have put it up to the workman. On the other hand, the workman is apt to regard time study as spying upon him, and a reflection upon his integrity. Indeed, time study has been characterized by some men in the ranks of labor as un-American; but such an opinion can only be regarded as being based on ignorance of the subject, or on bias. If to seek the truth were un-American, then time study might be.

The workman's suspicion and opposition may be justified where time study is grafted onto the old type of management, as has frequently been attempted by the manager, who, having heard enthusiastic accounts of what has been accomplished under Scientific Management, with a "little knowledge" (proverbially a dangerous thing), concludes that while he cannot see the advantage of all the features of the "System," time study is a good thing, and that he will adopt it. It is apparently as a result of "setting rates" for piece work or bonus work that increased output is achieved; so he calls into his office a bright but inexperienced young man, and tells him to start making time study and setting rates. Just as likely as not the "bright young man" intuitively realizes that may be the workman will not like it, and may gently, but firmly impress his objection upon him with a monkey wrench or hammer, so he tactfully concludes that it will be best not to annoy the men by letting them know what he is doing. Therefore he hides back of a post while making his "time study," or else, keeping his watch and his hands in his pockets, affably endeavors to persuade the workman that he is not at all interested in anything that is going on within a radius of many miles.

It is this kind of "time study" that arouses the workman's ire, and which has brought forth from those who have encountered it and know not the right kind, the contention that it is un-American in spirit. In this view the man is amply justified, for not only is such "time study" worthless, but positively vicious and an insult to the workman's intelligence. Just the minute the time study man undertakes to deceive, he gives the workman license to deceive him. The workman may then loaf and make as many false moves as he pleases, but the time study man, if such he may be called, has put himself in a position where he cannot object. Instead of two men coöperating in a quest of truth, such misguided attempts at time study become a covert battle of one man's wits against another's, resulting in mutual distrust where confidence should exist.

There are two classes of time study:

1. That which is made for the purpose of ascertaining what is wrong with a process as it exists.

2. That which is made after conditions have been standardized, and the best method established.

The first is more correctly motion study, as its prime object is to discover delays, false or unnecessary motions, and their causes, and this is the sort of time study that should be first undertaken. It should result in the improvement of conditions, and the establishment of standards. It is the first step in the development of a science.

A simple illustration or two may help to make this clear. In one of the plants in which the writer took a part in the installation of the Taylor System, we selected a simple operation on which to make our first time study. Briefly, this operation consisted of putting a roll of cloth into a machine, which, when properly set, automatically cut it up into pieces of the required size.

In making a study of this operation, the following things came to light:

1. The operator had to walk a distance of about twelve feet to secure the roll of cloth required. To remedy this, a suitable rack was provided, close to the machine, on which a laborer kept supplied the cloth for three jobs ahead.

2. It was necessary for the operator to set, for each new job (so as to cut the cloth to the required width), eight to sixteen circular knives, loosening a screw in each, sliding it along a shaft, measuring the distance between the knives and tightening the screws. The operator was expected to provide his own screwdriver and rule, and, as a matter of fact, any other tools he might need. From the time study of this part of the operation it was found that the screwdriver used by the operator was too long for the job, resulting in fumbling; that it was of an inferior quality of steel, so soft that after being used for several jobs the end became twisted, and the operator had to leave his work to grind or file it to shape. Some of the knives fitted their shaft so tightly that it was quite a difficult matter to move them along the shaft; and measuring the distance from one knife to another with an ordinary foot-rule was slow, awkward and uncertain. To remedy these difficulties, the management took it upon themselves to provide screwdrivers of the right length, and of good steel; to have the knives made to properly fit the shaft; and to provide a gage which could be readily and accurately set to the width of cloth to be cut, and so constructed that it was only necessary for the operator to place one end against the first knife set, and move the next up until it touched the other end of the gage.

3. It was found in setting the shear for cutting the strips of cloth to length, that it was necessary to loosen a nut. To do this the operator used a monkey wrench, which incidentally he provided himself, and which he had to adjust to the size of the nut. This wasted time, so the management did the obvious thing and replaced the ordinary hexagon nut with a wing nut which could be loosened and tightened with the hand without the need of a wrench.

4. It was found that the rolls of cloth supplied by the mill contained, instead of one continuous length, several pieces to a

roll, making it necessary to re-thread the cloth into the machine every time an end was reached. To remedy this, the mill was told that only one-piece rolls would be accepted, with the result that they furnished one-piece rolls.

This illustration embodies all of the principles of Scientific Management. As a result, the operator turned out twice as much work under the improved conditions as formerly, and with less worry, and little, if any, greater effort.

It may be well, however, to point out that it would have been futile to have made this time study until a routing system had been developed that would insure the workman being kept constantly supplied with materials, so that he would not have to waste time between jobs. This operator worked upon from ten to twenty different jobs a day.

Let us take another case in a totally different line of business — that of winding magnet coils for small electrical apparatus — resulting in almost as great an increase in output as the case just cited. A study of this operation showed that one-third of the operator's time was wasted, and through no fault of the operator. Twenty-one per cent of the operator's time was found to be wasted on account of defective material, and as this was scattered through the day's work, no one realized, until it was shown up by time study, how great the loss in output from this cause was. In fact, it was regarded as one of the minor troubles. It was found that operators had to leave their machines to procure materials that should have been brought to them; that many of the spools of wire would not fit the machines; that the operators were handicapped through having no convenient place for their materials, for their finished products, or for their tools. Their tools and machines were found to be in bad condition, and some of the tools provided were found to be unsuitable for the work.

In both of the cases just cited, the conditions found had existed for a long time, and, without making a minute time study, it is doubtful if the management would have ever realized the necessity for correcting them. With definite and reliable information to work upon, however, it was possible to almost entirely eliminate the difficulties.

These two illustrations are but one step beyond Mr. Taylor's illustrations of handling pig-iron and shoveling.

After making time studies of the class just described, the next step is to correct the faults in materials, methods and implements that have been brought to light, and establish standards and provide means for keeping up the standards. Then assuming that a routing system has been developed to the stage that will insure the workman's work being planned ahead, materials, information and proper tools always being at hand when wanted, time study may be undertaken for the purpose of setting tasks, and the payment of a reward for the task's accomplishment may be started.

Many people have misunderstood time study to mean ascertaining and recording the time required to perform any given job. This is not at all what we mean by elementary time study. In describing just what is meant by elementary time study, the writer will draw upon the machine shop for his illustrations, and leave it to the reader to draw his own analogies with regard to the lines of industry in which he may be interested.

All machine work may be divided into the following classes:

(*a*) Work done by a machine.

(*b*) Work done by the workman.

The time that machine work should take, or the actual cutting time, may be easily calculated, and, where tools, materials and machines are standardized, may be reduced to slide rules. The work done by the workman, or the handling time, must be arrived at in another and more difficult manner.

Handling time in machine shop work, and in most other manufacturing processes, may be classified under three heads:

1. The handling of tools used in connection with the work.
2. The handling of the machine.
3. The handling of the material being worked on.

The first, handling of tools, is the greatest of the three, and may be roughly said, in general machine shop work, to represent 75 per cent of all handling time.

The second, handling of the machine, will represent about 15 per cent, and handling of materials about 10 per cent. These percentages, of course, will vary in different classes of work, and are given only for the purpose of illustration.

Handling of tools consists of such things as putting bolts, clamps, etc., on work; putting tools such as drills, reamers, turning tools, etc., into the machine; measuring with calipers, gages, scales, or dividers.

Handling of machines consists of such things as stopping and starting machines; changing the speed or feed; adjusting or setting various parts of the machine to suit the work to be done.

All of these elementary operations are done repeatedly on a great variety of jobs, and in many cases are the same for work done on totally different machines. These are what we make a time study of, and not any one job as a whole, which is simply a combination of a number of different elements. For instance, we must start and stop the machine several times in doing any job; consequently, we should study the starting and stopping of each machine on each of its various speeds, and record the time under that heading for each machine.

For any drill press job we must put drills of one or more sizes into the spindle, and remove them after the holes are drilled; consequently, we should study the time required to put in and take out drills of each size. This will apply on a great variety of jobs done in various drill presses, and in any shop, that is, provided proper standards have been established.

The greatest difficulty encountered in connection with this branch of Scientific Management in the past was the classification and tabulation of the data accumulated in such a manner as to make it readily available for use on future jobs, differing as a whole, or in part, from those upon which the observations had been made. In plants having a standard line of product, doing the same kind of work year after year, this was a comparatively simple matter, as there the data could be classified and filed according to the product; and in such a plant changes are infrequent and usually affect only certain details, necessitating only a study of the parts of the work affected.

Likewise, in industries where each machine performs only one simple operation which is essentially the same on all work —

although the job itself may be different in many respects, this problem is comparatively simple, and the elementary data may be classified and filed under the headings of the different machines. A good example of this type of work is stamping or punching sheet metal parts, which might be analyzed into the following elements, which, for a given size and type of machine, would be common to all work done in the machine:

Putting in dies;

Adjusting stops, guides, and stroke of machine;

Feeding materials into machine;

Working time of machine.

Of course, each of these might be further sub-divided.

It is in general machine shop work, however, that the problem of classifying and tabulating data becomes especially difficult, and the greater the variety of the product the greater the difficulty. This is due to the comparatively large number of different elements that may be involved, and the almost infinite number of combinations of these elements. For example, on a drill press, one job may be the drilling of a single hole in a block of iron, consisting of a very simple adjustment of the machine, clamping the work with a single bolt and clamp, putting one drill into the spindle, starting the machine, letting the drill run through the piece, stopping the machine, removing the piece and the drill. The next job may include the drilling, tapping, and reaming of a number of holes of several different sizes (counter-boring some of them) on different surfaces of a complicated piece of work, necessitating several elaborate settings, and many careful measurements. This job would include all of the elements entering into the first, and many more in addition. There is one saving grace, however, due to the fact that in spite of its complication there are a number of elements that repeat themselves a number of times in almost every job.

To give a more definite idea of the nature of elementary time units and their use, the author will show a few examples of instruction cards, outlining in detail the method to be followed in performing certain jobs and giving the time for each element.

These cards are not the result of a time study of the specific jobs, but were made up from the drawings of the parts on which the work was to be done before any of the parts were made. The elementary time units were previously studied in connection with previous jobs, or individually, some of them in shops other than the one in which the work in question was done.

This represents planning of an advanced type, and cannot be done, as has been already pointed out, until conditions have been standardized, so that the machine in which the work is to be done may be depended upon to be in first class condition (as it was at the time the study of the elementary time units was made), that all tools are in first class condition and are supplied to the operator in advance, ready for use; that materials are always at hand, and placed conveniently for the operator, etc.

This is one instance of the assumption of responsibility by the management, and of the management's coöperation with the workman.

Under the old type of management, the workman was responsible for having at his machine, or securing as required, such tools as he needed for each job, and was expected to have them kept in good condition. The difficulties in the way of the workman's meeting these responsibilities were tremendous, and little or no help did he receive from the management as represented by the foreman, who was so harassed with details, and generally overloaded with work, that it was a physical impossibility for him to do much for the workman, even though he recognized the importance and necessity for doing so.

Under such conditions, it was difficult and annoying for the workman to keep his machine and tools in good condition, as he could only call attention to the need of repairs or new tools, and was dependent upon others taking enough interest and taking the trouble to have them attended to; and as many of the things he endeavored to have done were inevitably neglected or lost sight of, he frequently became hopelessly discouraged and lost interest in attempting to have things right. Such effort as might be made by the workman to maintain conditions was, in any event, at the expense of output from that unit of the plant

CLASSIFIED ELEMENTARY TIME UNITS FOR FITTING DRILLS WITH OR WITHOUT SLEEVES USED EITHER IN SPINDLE OR IN SOCKET ALREADY IN SPINDLE

DRILL WITHOUT SLEEVE							
Shank of drill, Morse taper	1	2	3	4	5	6	Put into spindle or into socket already in spindle — no sleeve used.
Time for putting drill in, in minutes	0.26	0.26	0.26	0.27	0.30		Time given in this section to be used when drill is put into spindle or socket.
Select drill from tray or table	0.10	0.10	0.10	0.10	0.10		DSSS already in spindle where no sleeve is necessary to make shank fit bore.
Put drill into spindle	0.04	0.04	0.04	0.05	0.07		
Put wood block under drill either on work or table	0.02	0.02	0.02	0.02	0.02		
Force drill up hard into spindle by pulling down on lever	0.08	0.08	0.08	0.08	0.09		
Remove block	0.02	0.02	0.02	0.02	0.02		
Time for removing drill, in minutes	0.10	0.10	0.10	0.10	0.14		Remove from spindle or from socket in spindle
Pick up hammer and drift	0.04	0.04	0.04	0.04	0.04		
Knock out drill from spindle	0.04	0.04	0.04	0.04	0.08		
Replace tools on table or in tray	0.02	0.02	0.02	0.02	0.02		
DRILL AND ONE SLEEVE (ALREADY ASSEMBLED)							Put into spindle drill and one sleeve already assembled.
Outside taper of sleeve	1	2	3	4	5	6	(For time to put sleeves on drills see Sheet DSSC)
Time for putting drill and sleeve into spindle, in minutes		0.26	0.26	0.27	0.30		All sleeves to be put on drills before starting job.
Select drill from tray or table		0.10	0.10	0.10	0.10		*General Note.*— Socket DSSS should be used where several drills with same size shank are to be used in succession.
Put drill and sleeve into spindle		0.04	0.04	0.05	0.07		
Put wood block under drill either on work or table		0.02	0.02	0.02	0.02		
Force drill and sleeve up hard into spindle by pulling down on lever		0.08	0.08	0.08	0.09		
Remove block		0.02	0.02	0.02	0.02		
Time for removing drill and sleeve, in minutes		0.10	0.10	0.10	0.14		Remove from spindle drill and sleeve not separated
Pick up hammer and drift		0.04	0.04	0.04	0.04		(For time to separate drill and socket see Sheet DSSC)
Knock out drill and sleeve		0.04	0.04	0.04	0.08		All sleeves are to be removed from drills after job is finished.
Replace tools on table or in tray		0.02	0.02	0.02	0.02		

represented by the workman and the machine he was employed to operate.

With the proper coöperation and assumption of responsibility by the management, however, the workman is relieved of all this, and can devote his undivided attention to the work for which he is employed.

Under Scientific Management the machines are periodically inspected, repaired, and adjusted before they have had time to get into a condition that prevents their efficient operation. Instead of the foreman looking after this important matter — as an incidental that may be disregarded if other things appear to be of greater immediate importance — it is made the sole function of a repair boss.

All tools are kept in a tool room, from which they are issued for each job, and returned after being used. The tool room foreman is responsible for seeing that no tools are issued that are not up to the standard, and in place of the responsibility for the maintenance of standards being widely scattered among the entire working force, who lack the means, and in some cases the incentive, for its enforcement, we have this responsibility concentrated in one man, who represents the management.

The author trusts that he has made clear the necessity for standardized conditions and functional foremanship being established before any attempt is made to inaugurate any system of task work based on elementary time study. To make this still more emphatic, let us see what would happen if this were ignored.

Suppose we were, in a shop run the old way, to make a study of drill press work, and after our preliminary investigation had the machine, tools, etc., put into first class condition, and then made a careful study of the time the various elementary operations should consume under proper conditions. A certain amount of time passes before we make use of the data collected, and we then set tasks, based on the result of our observations, for various jobs to be done on the drill press in question, and one of these tasks is assigned to the workman.

The first thing he is required to do may be to adjust the height of the arm of his machine. We have allowed the proper time for picking up a wrench of the right size from a tool stand, and loosening the bolts that secure the arm; but since we made

TOOL LIST FOR MACHINE NO. D 1		OPERATION SYMBOL 2 N 2 C 2 C	DRAWING NOS. 6-28-2

Tools called for on this tool list must be issued in a tote box. The list should be placed in the tag pocket on the box and accompany the tools to and from machine.

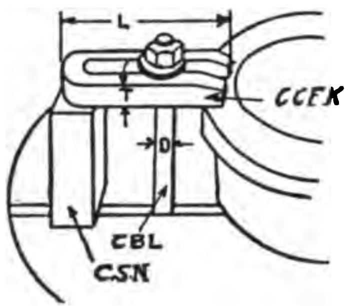
PIECES	NAME	SIZE	TOOL SYMBOL
4	Bolts	5/8×4	C B L
	Vise		
	Chuck		
	Carrier		
4	Clamps	5/8×5	C C F K
	Mandrel		
4	Blocks	1½	C S N
2		1½×3×29½	C S P
	Boring Cutters		
8	Drills	17/32	D D T T
	Collet		
	Counter Bores		
	Reamers		
	Arbors		
	Die Head		
	Boring Bars		
1	Sleeves	1-4	D S S C
1		3-4	D S S C
	Sockets		
1		#1	D S T H
2	Driver	5/8	D T S
	Tap Holder		
1	Taps	#1½	H H M
1		#1	H J D
1		#3	H J D
1	Gages	#4	H J D
	Dies		
	Cutting Tools		
	Milling Cutters		
	Jig		
1	Wrench	5/8	W F H H

	Man's No.	Hour	Month	Day	Year	Signed
Checks required.............			10	6	'11	R.

When the tool list is not correct the gang boss must at once report the error to the man who signed this list.

our observations the wrench has disappeared, having been borrowed by a fellow workman, or mislaid. Our workman then falls back upon his trusty monkey wrench, which is his own property, and which he has therefore guarded with care, and

CLASSIFIED ELEMENTARY TIME UNITS FOR CLAMPING WORK TO DRILL PRESS TABLES



MEDIUM SIZE C C F K

Diam. of bolt, in. D	Length of clamp, in. L	Thickness of clamp, in. T	Weight of clamp, lb.	oz.
⅝	10	1¼	3	11
¾	11	1½	6	—
⅞	12	1½	7	8
1	13	1¾	10	8

Diameter of bolt, inches	⅝ and ¾				⅞ and 1					
Length of bolt, inches	6	12	14	18	6	12	18	24	30	36
Time for clamping, minutes	0.42	0.45	0.45	0.51	0.48	0.53	0.57	0.69	0.78	0.92
Lift bolt, clamp and block to table (bolt remaining in hand)	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.13	0.14	0.17
Put bolt in slot	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.06	0.07
Slip clamp on bolt and on work	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
Put block under clamp	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.07	0.08	0.10
Screw nut down with fingers	0.05	0.06	0.06	0.07	0.06	0.07	0.08	0.10	0.11	0.14
Tighten nut lightly with wrench	0.08	0.08	0.08	0.10	0.11	0.12	0.13	0.15	0.17	0.19
Draw down nut tight with wrench	0.09	0.09	0.09	0.10	0.09	0.10	0.11	0.13	0.15	0.17

Clamping. — Bolt to be put in slot.

The time given in this section to be used *only for first piece* in lot or on other pieces *when bolt has to be put in slot.*

Time for removing, minutes.........	0.16	0.17	0.17	0.18	0.22	0.22	0.24	0.26	0.29	0.33	*Removing.* — Bolt not to be taken from slot. The time given in this section to be used for all pieces in lot *excepting the last piece.*
Loosen nut with wrench...........	0.11	0.12	0.12	0.13	0.17	0.17	0.19	0.20	0.22	0.25	
Remove clamp from bolt	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08	
Time for clamping, minutes..........	0.30	0.33	0.34	0.37	0.35	0.39	0.42	0.51	0.58	0.68	*Clamping.*— Bolt already in slot. The time given in this section to be used for all pieces in the lot *after* the *first piece* when bolt has not been removed.
Slip clamp on bolt and on work....	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08	
Put block under clamp............	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.07	0.08	0.10	
Screw nut down with fingers.......	0.05	0.06	0.06	0.07	0.06	0.07	0.08	0.10	0.11	0.14	
Tighten nut lightly with wrench....	0.08	0.08	0.08	0.10	0.11	0.12	0.13	0.15	0.17	0.19	
Draw nut down tight with wrench..	0.08	0.09	0.10	0.10	0.09	0.10	0.11	0.13	0.15	0.17	
Time for removing, minutes.........	0.24	0.25	0.25	0.27	0.30	0.30	0.33	0.37	0.41	0.47	*Removing.* — Bolt to be taken from slot. The time given in this section to be used *only for last piece* in lot, or on other pieces *when bolt has to be taken from slot.*
Loosen nut with wrench...........	0.11	0.12	0.12	0.13	0.17	0.17	0.19	0.20	0.22	0.26	
Remove clamp from bolt..........	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	
Remove bolt from slot............	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.05	0.05	
Put clamp, bolt, and block in tote box on floor....................	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.08	0.10	

consumes as much time adjusting it as should have been consumed in the entire job of loosening the bolts had a wrench of the right kind been available; this alone might be enough to prevent his accomplishing the task in the time allowed.

Next, he places the piece to be drilled on the table of his machine, and selects a clamp and bolt of the proper length from the box or rack in which he keeps them. The bolt selected has no nut on it, so he takes one off another bolt and, after placing his bolt and clamp in position, starts to screw the nut on. He finds that it sticks, due to the thread on the bolt having been damaged, and instead of being able to screw it on rapidly with his fingers, he is obliged to take a wrench and laboriously work it down the entire way. It is also probable that the trusty monkey wrench has to again be called into action, by reason of the absence of one of the right kind and size. When our time study was made, we found that under proper conditions 0.71 minute was to be the proper time for putting on this bolt and clamp, but owing to those conditions not being maintained, the best the workman could do took anywhere from two to ten times as long. It is no exaggeration to say that we have seen a workman spend fifteen minutes in trying to screw a nut onto a clamping bolt.

Our observations of this one item showed as follows:

	Minute
To lift the bolt, block and clamp to the table of the machine took	0.07
To put the bolt in slot of table	0.04
To remove the nut from bolt by unscrewing with the fingers took	0.13
To put clamp over bolt and on work	0.05
To put block under clamp	0.05
To put washer on bolt	0.07
To screw nut on bolt with fingers	0.13
To tighten nut lightly with wrench	0.07
To draw nut down tight with wrench	0.10
Total time required	0.71

To follow through each step of the operation in this manner would take too long, and the two points cited are typical of what might be expected at almost every stage of the work. The picture is in no sense overdrawn; if anything, the reverse is true.

Instruction cards such as those used for illustrations are the second step in the planning of the work. Before they are made up, the work as a whole has been laid out or routed; the various operations to be performed on each piece of work have been determined, as well as their sequence, and also the machines in which they are to be performed.

The method followed in making up instruction cards for new work, then, is as follows (assuming, of course, that all elementary time study data are available, and properly classified and tabulated):

The man in charge of this part of the planning — who must, of course, be an experienced and practical man, selected by reason of his qualifications for the work — has before him the drawing of the part to be machined. His first step is to decide upon the general method to be followed in the operation being planned. In doing this, two or more methods may suggest themselves, bringing up a question as to which is the best. In this event, he will add up the time for each of the elements entering into the different methods, and select the one that gives the smallest total time.

He next sets down on the instruction card a description of the job, element by element, in their proper sequence, going through the operation just as he would at the machine itself. As he does so, he draws off a list of the tools required, which will be sent to the tool room before the job is to be done, and the tools delivered to the workman. After having put down on the instruction card all of the elements to be done, he turns to his data file, and indexed under the machine number he finds the time for each of the adjustments or manipulations of the machine. Under the tool symbol he finds the time for each of the elements involving the use of a tool, while under the classification of material shapes, he finds the time for handling pieces of the same approximate shape and weight as the one under consideration.

INSTRUCTION CARD FOR OPERATION — SYMBOL 1PLV3P

1 SHEETS, SHEET NO. 1 — DRAWING NO. 6601.105 — MACHINE NO. L10 — ORDER NO. PLVP

MATERIAL, STEEL — CLASS NO..... — PIECES IN LOT, 400 — TIME FOR LOT, 393.61 — BONUS.....

DESCRIPTION OF OPERATION: DRILL AND CUT OFF

Item	Detailed Instructions	Feed	Speed	Element time per piece	Time for entire lot	Continuous or running time
1	Change card				2.00	
2	Learn what is to be done				2.00	
3	Change jaws to ⅝				.91	
4	Put collar on stock				.19	
5	Put stock in spindle and adjust collets				.59	
6	Set stop for length				.31	
7	Put CCCE ⅝ in turret head				.31	
8	Put DDTS 3/16 in CCCE ⅝				.22	
9	Set stop for DDTS 3/16				.31	
10	Put in PATL tool and set				.77	
					7.61	
11	Set stock to stop			.15		
12	Turn turret and start machine			.08		
13	Drill 3/16 hole, 3/16 run	HF	5.36 1F	.14		
14	Turn turret			.08		
15	Cut off piece and round corners with file	HF	1F	.12		
16	Put piece in tote can			.02		
17	Count every 100 pieces. Time per piece =			.02		
				.61		
	90% on handling time .35			.32		
	10% on machine time .26			.03		
				.96		

Disassemble 2.00

Time for lot = (number of pieces × .96) + 2.00 + 7.61

Time for 400 pieces = 393.61 or 66 tenths + 2.00 + 7.61.

REV. PER MIN.

WHEN MACHINE CANNOT BE RUN AS ORDERED, MACHINE BOSS MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD

Month	Day	Year
1	9	11

Signed R.

Checked

INSTRUCTION CARD FOR OPERATION

SYMBOL 2 N 2 C 2 C

1 SHEETS, SHEET NO. 1 DRAWING NO. 6-28-2 MACHINE NO. D1 ORDER NO. N 2 C C

MATERIAL, C I. CLASS NO..... PIECES IN LOT, 200 TIME FOR LOT, 302.62 BONUS.....

DESCRIPTION OF OPERATION: DRILL AND TAP

Item	Detailed Instructions	Feed	Speed	Element time per piece	Time for entire lot	Continuous or running time
1	Change card........				2.50	
2	Learn what is to be done........				6.00	
3	Assemble drills and sleeves........				.48	
4	Clamp 2CSP 1½×3×29½ across table 2½ in. apart equidistant to center hole of table........				.81	
6	Put 17/32 drill and sleeve in spindle........				.27	
7	Raise or lower head........				.71	
8	Change speed and feed start machine........				.40	
					11.17	
9	Pick up piece and put on table over centre hole........			.03		
10	Spot 17/32 hole........	1F	1B	.10		
11	Drill 17/32 hole 1 in. run........	B	1B	.48		
12	Put piece on floor........			.02		
13	REPEAT ITEMS # 12 TO 15 ON EACH PIECE IN LOT					
14	Take out drill and sleeve and put in DSTH # 1 and sleeve........				.45	
15	Pick up piece and put on table over center hole........			.03		
16	Put tap in fixture and set........			.09		
17	Start machine........			.03		
18	Tap with second tap........	1F	1B	.34		
	NOTE: — ALLOW TAP TO GO ALL THE WAY THROUGH.					
19	Put piece in tote box........			.02		
20	Stop machine and pick up tap........			.06		
21	Stop machine, change drills and start machine every 20 pcs. time per piece........			.03		
				1.23	.45	
	40% on handling time .31........			.12		
	10% on machine time .92........			.09		
				1.44		

Disassemble 3.00.

Time for lot = (# of pcs. × 1.44) + (3.00 + .45 + 11.17).

Time for 200 pcs. = 302.62 or 50 tenths.

	10	8	11	
WHEN MACHINE CANNOT BE RUN AS ORDERED, MACHINE BOSS MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD	Month	Day	Year	Signed R.
				Checked ....

INSTRUCTION CARD FOR OPERATION — SYMBOL 1PLV3P

1 SHEETS, SHEET NO. 1 — DRAWING NO. 6601.105 — MACHINE NO. L10 — ORDER NO. PLVP

MATERIAL, STEEL — CLASS NO..... — PIECES IN LOT, 400 — TIME FOR LOT, 393.61 — BONUS.....

DESCRIPTION OF OPERATION: DRILL AND CUT OFF

Item	Detailed Instructions	Feed	Speed	Element time per piece	Time for entire lot	Continuous or running time
1	Change card				2.00	
2	Learn what is to be done				2.00	
3	Change jaws to [illegible]				.91	
4	Put collar on stock				.19	
5	Put stock in spindle and adjust collets				.59	
6	Set stop for length				.31	
7	Put CCCE [illegible] in turret head				.31	
8	Put DDTS 3/16 in CCCE [illegible]				.22	
9	Set stop for DDTS 3/16				.31	
10	Put in PATL tool and set				.77	
					7.61	
11	Set stock to stop			.15		
12	Turn turret and start machine			.08		
13	Drill 3/16 hole, 3/16 run	HF	5.36 1F	.14		
14	Turn turret			.08		
15	Cut off piece and round corners with file	HF	1F	.12		
16	Put piece in tote can			.02		
17	Count every 100 pieces. Time per piece =			.02		
				.61		
	90% on handling time .35			.32		
	10% on machine time .26			.03		
				.96		

Disassemble 2.00

Time for lot = (number of pieces × .96) + 2.00 + 7.61

Time for 400 pieces = 393.61 or 66 tenths + 2.00 + 7.61.

REV. PER MIN.

WHEN MACHINE CANNOT BE RUN AS ORDERED, MACHINE BOSS MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD

1	9	11	Signed R.
Month	Day	Year	Checked

INSTRUCTION CARD FOR OPERATION — SYMBOL 2 N 2 C 2 C

1 SHEETS, SHEET No. 1 — DRAWING No. 6-28-2 — MACHINE No. D1 — ORDER No. N 2 C C
MATERIAL, C I. — CLASS No.... — PIECES IN LOT, 200 — TIME FOR LOT, 302.62 — BONUS.....

DESCRIPTION OF OPERATION: DRILL AND TAP

Item	Detailed Instructions	Feed	Speed	Element time per piece	Time for entire lot	Continuous or running time
1	Change card				2.50	
2	Learn what is to be done				6.00	
3	Assemble drills and sleeves				.48	
4	Clamp 2CSP 1¾×3×29¾ across table 2¾ in. apart equidistant to center hole of table				.81	
6	Put 17/32 drill and sleeve in spindle				.27	
7	Raise or lower head				.71	
8	Change speed and feed start machine				.40	
					11.17	
9	Pick up piece and put on table over centre hole			.03		
10	Spot 17/32 hole	1F	1B	.10		
11	Drill 17/32 hole 1 in. run	B	1B	.48		
12	Put piece on floor			.02		
13	REPEAT ITEMS # 12 TO 15 ON EACH PIECE IN LOT					
14	Take out drill and sleeve and put in DSTH # 1 and sleeve				.45	
15	Pick up piece and put on table over center hole			.03		
16	Put tap in fixture and set			.09		
17	Start machine			.03		
18	Tap with second tap	1F	1B	.34		
	NOTE: — ALLOW TAP TO GO ALL THE WAY THROUGH.					
19	Put piece in tote box			.02		
20	Stop machine and pick up tap			.06		
21	Stop machine, change drills and start machine every 20 pcs. time per piece			.03		
				1.23	.45	
	40% on handling time .31			.12		
	10% on machine time .92			.09		
				1.44		

Disassemble 3.00.
Time for lot = (# of pcs. × 1.44) + (3.00 + .45 + 11.17).
Time for 200 pcs. = 302.62 or 50 tenths.

WHEN MACHINE CANNOT BE RUN AS ORDERED, MACHINE BOSS MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD — 10 Month — 8 Day — 11 Year — Signed R.

Checked ....

Making Time Studies

The writer has, as yet, said very little with reference to the actual making of time studies. In general, it may be said that the man undertaking this work should be as familiar as possible with the work being studied, and if he has actually worked on the jobs being studied, so much the better. All other things being equal, a man who has worked at, and is skilled in the trade under consideration, makes the best time study man.

Next to the skilled workman, the best time study man is a chemist, whose training has impressed upon him the importance of exactness, and of little and apparently insignificant points. The chemist has also learned how to analyze things into their elements. The best possible time study man would, in the writer's estimation, be a chemist possessing practical experience in the work being studied.

The equipment required is very simple, consisting of a decimal stop watch that can be stopped at any point, started from the same point, or snapped back to zero at will. We have found it necessary to have these watches made especially, and Mr. Sanford E. Thompson, whom we of the Taylor Group regard as the foremost time study man in the country, has, for a number of years, taken upon himself, as a matter of accommodation to the rest of us, to keep a supply of these watches on hand, from which he has supplied our needs, and those of our clients; and I take this opportunity to publicly acknowledge the debt we owe him for doing so.

In addition to a watch, the only other equipment required is a board for holding the watch and the sheet of paper on which the observations are recorded. Several different forms of time study observation sheets have been developed, but essentially they are all the same, providing first a column in which are entered the various elements to be observed in the order of their occurrence, and then a series of columns in which are entered the time consumed by each in each series of observations.

If an operation is one that is repeated over and over again, the way to study it is to first list the elements entering into it, and then take the time on each with the watch running, stopping it in case of false movements, or anything going wrong, and starting it again when the actual work is resumed. When the observations have been completed, the time for each element is computed by subtraction, and the time for each element ascertained. Wherever possible, a number of observations should be made on each sequence of operations, and in determining the elementary time unit, we eliminate the times that are too high and too low — usually as a result of error in observation — and follow the general rule of selecting the time unit that occurs most frequently for each element.

An expert time study man can observe a sequence of elements totally new, and put down a description of the element and its time as the operation progresses; but this is no task for the beginner.

SCIENTIFIC MANAGEMENT IN RETAILING

By C. BERTRAND THOMPSON

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Introduction

Running a retail store by scientific management is an idea quite new to store managers. They have heard of scientific management and the possibility of its application to railroads, and they know that factories and a few government establishments are being operated under scientific management. The popular idea of this particular development is that it consists in the application of stop watches and motion study to the work of operatives and the administration of a factory with an excessive amount of red tape.

One would not have to reflect long, however, to arrive at the conclusion that, if this is all scientific management consisted of, it would have died a natural death long ago, instead of being, as it is, the livest issue in modern industrial developments. Scientific management includes time study and motion study and an elaborateness of forms and records which to the uninitiated bears naturally the appearance of red tape. But these things do not constitute the system; they are merely parts of the mechanism. The system itself consists of a series of principles whose application, as made by Fred W. Taylor and his group of engineers, is but one particular form. The mechanism is in many cases not adaptable to retailing, but the principles are.

Any one familiar with the fine arts is thoroughly used to the idea of transferring the principles of one art to another. Take the principle of contrast, for example, originating probably in dramatic literature, where the interplay of opposing characters stimulated a pleasurable interest. This same principle of contrast was soon extended to architecture and sculpture and later to painting, and in modern times to music. The fact that the aim sought in any fine art is the same in all of them: to wit, an aesthetic pleasure, suggests that the means successful in one would probably be successful in another; and experience has justified this supposition. It is reasonable to suppose that the same principle would apply to the art of management, whether it is management of a factory or a store. In both cases the end sought is the same: to wit, the production of a utility at the lowest cost. In the case of a factory the utility takes the form of a change in the shape and condition of the materials handled; they go in, for instance, as bales of cotton and come out as bolts of cloth. The thing produced is the change in form. In a store the product is also a utility, but a utility of location. The goods arrive in packages at the store, where they are wanted only for distribution, and are sold in units to the customer who wants them for use. The only change they have experienced is the change in location; but as this is a useful change, it is a utility, exactly as the change in form made by the factory.

Besides producing the same thing: to wit, utilities, both factory and store make use of the same producing factors — men, materials, equipment, and buildings. Instead, therefore, of its being difficult to see how the principles of factory management can apply to store management, it is rather more difficult to see how they can fail to apply.

The fundamental principles of scientific management as practised in industrial establishments are: first, the organization of the present scattered knowledge in regard to the business into a coherent science; and, second, the organization of the human and material factors involved to secure the most efficient application of the science.

That there is a science of production has been known to engineers and factory managers for decades; and that this science includes not merely the chemistry and physics of engineering, but the technique of machine operation and hand work has been demonstrated for years under scientific management. As Mr. Taylor has shown, there is a science of shovelling as well as a science of bridge building — simpler, of course, but none the less ascertainable and definite. There is a science of selling, too, and many people are trying to find out what it is, thus recognizing the application of this manufacturing principle to marketing.

The principal methods in a scientifically managed factory for securing proper organization of the human and material factors include: first, the selection of the right men for the job; second, the systematic training of each man for his job and for transfer to other jobs when needed; third, an accurate determination of a definite quantity and quality of work which each man may reasonably be expected to produce, day in and day out, without inconvenience; fourth, the establishment of such conditions as will in every way facilitate the work of the operator, such as careful planning of all work in advance and having on hand at the machine or work place all the materials, tools, and instructions necessary for the workman to proceed; fifth, the payment of a wage sufficiently above the ordinary to be an inducement to the workman to accept the instruction and other facilities offered him.

Some of these methods are already familiar to store and sales managers and have been consciously developed, in some cases to a high degree of perfection.

Though it cannot be said that the selection of sales people, buyers, and the force of help about a store, is done on any noticeably scientific basis, it is evident that considerable thought has been given to the training of such people as are actually employed. Classes in salesmanship are quite common. Committee meetings of buyers, etc., practically amount to the same thing; and frequent conferences between the heads of a concern and their subordinates are in many stores the occasion of definite instruction. Conventions of salesmen are utilized for the same purpose. Thus the second method has secured considerable recognition.

The establishment of a quota of sales, whether as the basis for the tenure of a job or the fixing of a salary, is a recognition of the third method: the establishment of a definite task.

Fixing the salary proportionally to the sales made, whether in the form of commission, bonus, premium, or what not, is in a degree a recognition of the fifth method — I say "in a degree" because the increased compensation in selling is usually paid simply for the product: to wit, the quantity of sales and not, as in factories operating under scientific management, for the acceptance of instruction and increased facilities provided by the management, bringing with it as a by-product an increase in output. Commission and premium schemes as applied to sales are more like the old piece rate system in factories. In the piece rate system some one sets a rate according to his judgment, and the worker is paid exactly in proportion to the number of pieces produced. The management does nothing in particular to assist him in production, but depends on the operator's initiative and ability to devise improvements and increase his output. This is evidently entirely different from the method of scientific management, which has standardized so far as possible all the conditions under which the operator works, trains him thoroughly to the best use of the conditions provided, sets a task based upon the continuance of such conditions, and pays a high rate for their acceptance.

It should be clear from this comparison that the feature in which sales management is most undeveloped in comparison with factory management is in the organization of the conditions in which the work is done. In other words, in the adequate performance of the duties which should devolve upon the management and which affect sales only indirectly. Take the stock-handling system of any large department store as an example. The store gives the best of its attention and ability to advertising, to the selection of buyers and the training of sales people; but its store and stockrooms are usually inadequate, poorly lighted, poorly located, poorly accounted for, and in general, in comparison with the factory storeroom, quite inefficiently managed. The expense connected with the management of a storeroom is charged as "non-productive" or "burden" and the idea, now becoming obsolete in factory management, that overhead or indirect expense is a burden and therefore to be reduced to a minimum, still prevails largely in marketing.

The same observations apply to the usual retail accounting systems. They are looked upon as a necessary evil. As much attention as is necessary is given to the commercial accounts — those by which the manager keeps posted on how much he owes and how much is owing to him. But of cost accounting, as that term is known to the factory manager, there is little or nothing; and yet it is reasonable to suppose that the same methods of cost accounting which have fully demonstrated their value in manufacturing might be at least equally useful if applied to selling.

It is the object of the articles in this series to point out how these two features of management work: to wit, cost accounting and the accounting for materials received, handled, and delivered, may be successfully transplanted from factories to stores; and it may not be superfluous to add that they are really an account of what the writer has already successfully accomplished.

I

Cost Classification for Retail Stores

Most department stores and large retail establishments have developed certain parts of their system to a high degree of perfection. The most immediate and important problem that they have is to buy the right goods at the right time, to get them before the customer and sell them as quickly as possible at a profit. The very life of the organization depends on the satisfactory solution of this problem; consequently, it has received the greatest share of attention and has been in many cases satisfactorily worked out. The buyers are carefully selected, well trained, closely checked, and highly rewarded. Dealings with manufacturers and sources of supply have been reduced to a science, until the manufacturers, especially the smaller ones, have become almost universally at the mercy of the large retailer, especially in respect to the making and storage of goods until called for, so that the manufacturer bears the burden of investment in stock which a few years ago was borne by the retailer. Advertising and display have similarly been highly developed, until the appeal of "special bargains," "quality," and "service" has become wellnigh irresistible. Schools have been installed and instructors retained to teach the sales-people the best method of closing with the customer. In short, some of the fundamental principles of what is known among manufacturers as scientific management have for some time been applied — more or less unconsciously and haphazard, to be sure — to retailing.

This situation is analogous to that which existed in industrial activities several years ago when the technique of production was receiving the lion's share of attention. The manufacturer considered that he existed to make the product and that his chief problem was to make it as quickly and as cheaply as possible. The product was apparently made " at the point of the tool " and it was therefore the technique of machinery, equipment and material that got his attention. It was at least twenty years ago, however, that manufacturers discovered that there was more involved in the economical making of a product than merely the machinery and the material. The propaganda of " costs " called his attention to the fact that the indirect expenses of his business constituted a large element in their real cost; and with this discovery came the resolution first to find out exactly what these indirect expenses were, and then to take the necessary steps to reduce them to the minimum consistent with efficient operation. This determination to eliminate wastes of equipment, materials, and later of effort is behind the whole modern movement of scientific management.

The time seems to be ripe for retailers to pursue the same course. Nothing is more striking to the student of industrial methods than the co-existence in the same store of the most refined methods of buying, advertising, and selling, with the very crudest methods of receiving, storing, handling, and delivery of goods, and the most cumbersome methods of accounting. The relatively greater profits in retailing — or perhaps the ignorance of the retailer as to the real extent of his profits — have succeeded in covering up the necessity for close supervision and the importance of detail. Retailers, however, are already bitten with the cost germ and are discovering that their profits are not quite what they thought they were. Or else they have begun to take pride in the efficient management of their business for the sheer artistic satisfaction that comes from doing a thing exactly right, and they appear to be at least in a receptive attitude toward scientific management.

As the store manager reads this and reflects on the great mass of printed forms, running into the hundreds, which he uses, he may wonder what these statements mean. It looks to him as though, if his store has anything, it certainly has system. It undoubtedly does have system of the type familiar to manufacturers fifteen years ago; that is, numerous and variegated cards and sheets, expensively ruled and highly colored. It is the very quantity and complexity of these forms and the clumsiness of their use which open him to the charge of wastefulness. Retailers should see what manufacturers have long since discovered; to wit, that efficient system does not consist in a multiplicity of forms, but in the quick, accurate, and economic securing of valuable results in the way of useful information in regard to the business, and more particularly in the reduction of wasted effort.

The extent of antiquated methods in the administration of retail establishments as revealed by recent investigations would almost lead one to question whether store managers are anywhere near ready for any form of scientific management. One gains reassurance, however, from the readiness with which shoe retailers are accepting and installing the uniform cost accounting system developed and provided for them by the Harvard University Bureau of Business Research. Reports from all over the country indicate that this system is not only being adopted bodily by leading shoe retailers but is also influencing the accounting system and business methods of many more. This cost system should lead retailers, as similar systems led manufacturers, to take the next step, which is to reduce the costs of doing business as soon as those costs are accurately ascertained.

As I have pointed out in former articles, the beginning of wisdom is analysis and classification. A classification once made is exceedingly useful and pays for itself many times over, as will be shown later. But even more valuable than the classification is the detailed analysis of the business which is necessary before classification can be begun. Before you can classify your costs, you must know exactly, exhaustively, and in minute detail what you are spending your money for; and the mere gathering of this information and putting it down on paper is in itself a startling eye-opener. Probably the first thing it will show is that from twice to five times more blanks and forms are being used than are necessary, and that, with proper management, the clerical force can be cut in half and quicker and more accurate results secured.

It will also undoubtedly show, in a fairly large store, that the stock of supplies of various sorts, such as wrapping paper, twine, elevator supplies, janitor's supplies, etc., is a considerable but indefinite quantity, scattered all over the place, and subject to no control whatever. If the store runs a soda fountain or a restaurant, an analysis of costs will probably show first that they (or at least the restaurant) do not pay; and an analysis of supplies will probably show a variety of brands and of prices and a laxity of control which may account largely for the deficit.

You undoubtedly have, or can easily get, a sufficiently good system of accounting for your merchandise. You know from your inventory the billed prices of your purchases, the freight and cartage on them, and the discounts. It is not so safe to wager that you know or can get easily the depreciation on your stock or the cost of returned goods in the course of a year; but even this you may have. If you are right up to the minute, you know the cost of heat, light, power, repairs and renewals of equipment, depreciation of equipment, office supplies and expenses; and of course it is easy to get your rent, insurance, taxes, and licenses, and management and office salaries. If you are running a small store as a unit, you can know, with this information in hand, whether you are making a profit. But if your store is departmentalized even to the slightest extent, it is reasonably certain that the indirect expenses are not being apportioned properly over your departments and, consequently, that you cannot tell which departments are running at a profit or at a loss and how much the profit or loss is per department. For you must remember that the mere accounting for merchandise does not give you this information. Your merchandise accounts may show a profit for a department which is in fact entirely wiped out by a proper apportionment of your indirect expenses; and it is precisely this indirect expense which store managers as a rule know little or nothing about.

The analysis and classification of costs which I am about to describe is intended to make it easy to determine the exact amount of indirect as well as direct cost and to provide a quick and easy method of apportionment of the indirect over the direct cost. It is not an easy and simple matter to make the analysis and classification. On the contrary, it calls for a great deal of thought and painstaking care. But as usual thoroughgoing planning means easy application; and that such is the case with this analysis and classification has been demonstrated. Applied to an up-to-date department store in which the manager got each month, from twenty to thirty days after the end of the month, an accurate distribution sheet, its first result was to get the distribution sheet five days after the end of the first month, and three days after the end of the second. It is now used to get a *weekly* distribution sheet laid on the manager's desk the first thing Monday morning.

For what kind of things does a store pay out its cash ? In the first place, of course, it pays salaries and its bills for merchandise, and in most cases rent, and interest on borrowed money. In addition it has many bills for freight, express and cartage, advertising, office supplies, wrapping and delivery expense, insurance and taxes, repairs and renewals of equipment. In addition to these actual expenditures, the store should have a proper charge for depreciation on stock and on fixtures. There will be many other tems of expense such as telephone and telegraph, elevators, janitor service, stockhandling, etc., and in some large stores, there may be such adjuncts as an employment department, an information bureau, waiting rooms, and perhaps even a bank. This does not exhaust the list by any means. Every store has an accounting department more or less developed, and occasionally has to meet legal expenses and to pay for protection against theft. One of its largest items is likely to be for advertising, including primarily newspapers, window-dressing, catalogues, and bill boards, and extending into a wide variety of special advertising accounts, such as contributions to charities, fairs, etc., dodgers, circular letters, programs, magazines, and gifts, such as playing-cards, fans, rulers, pencils, etc., inscribed with the name of the concern. To illustrate in further detail, the advertising department may employ special men of its own, requiring salaries and wages; there will be certain telephone and telegraph charges against this department alone; it will consume a considerable quantity of supplies and stationery, and in some cases may even maintain a small printing plant to set up large newspaper advertisements in advance.

The first principle of scientific management, you remember, is the organization of scattered knowledge into a systematized whole. Suppose we apply this principle to our accounts. Fortunately we can do this easily by the application of precisely the method which is used in developing a complete system of accounts for a factory, making of course such changes in the terminology as are obviously necessary.

The first thing to do is to list every item of expenditure that there is a record of — and there should be a record of every expenditure made. When this is accomplished, the next thing to do is to classify these items into a few very broad groups. This classification may be made by the aid of the questions on the chart. See page 554.

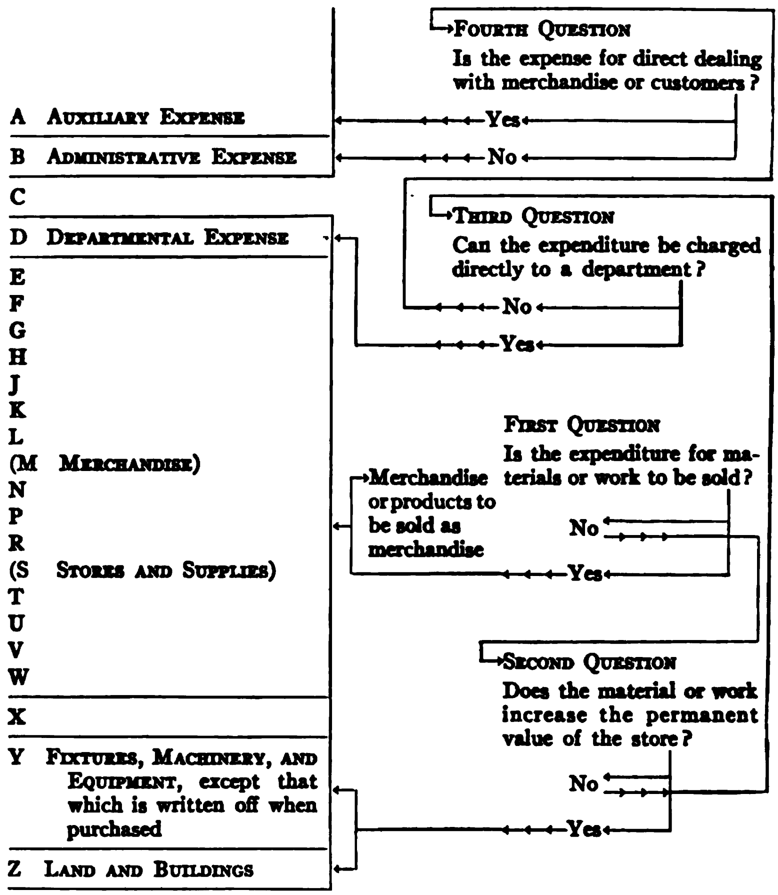
First question: Is the expenditure for materials or work to be sold? If the answer is Yes, it may be classified as an expenditure for merchandise or products to be sold as merchandise, such as the meals served in a restaurant. Such expenditure is direct expense; and as all other expenditures (except capital expenditures, such as permanent additions to land and buildings and equipment) are to be reckoned as a percentage of the selling price of the merchandise, all others are indirect.

If the expenditure is for materials or work not to be sold directly, a second question is in order: Does the material or work increase the permanent value of the store?

If the expenditure is for fixtures, machinery and equipment (except for that which is to be written off immediately when purchased) or for land and buildings, it should be classified as a capital account. If it is not for such items, nor for material or work to be sold, it is chargeable to some kind of indirect expense.

In the latter case there should be asked the third question: Can the expenditure be charged directly to a department? All expenditures which can be, may be classified at once as departmental expenses.

And in regard to those which cannot be charged directly to a department, the fourth question is in order: Is the expense for



direct handling of merchandise or dealing with customers? If it is, it may be classified as an auxiliary expense; and if it is not, then as an administrative expense.

The dividing line between auxiliary and administrative expense is somewhat shadowy; and in some cases it is immaterial which way the expense is classified, provided the classification, once made, is consistently adhered to. It has a certain usefulness, however, inasmuch as auxiliary expenses are by definition those which are necessary for the proper handling of goods and customers, and in case of retrenchment, therefore, these should be the last to be attacked. Administrative expenses, on the other hand, though necessary to the successful management of the business, may in many cases be cut down, at least temporarily, without serious harm.

An intelligent answering of these questions would result in a workable classification of every item of expenditure.

Adhering to the mnemonic system of symbols used in the Taylor system of scientific management and illustrated in former articles in this magazine, suppose that we make a base sheet for our major classification which will read as follows:

A	Auxiliary	N	
B	Administrative	P	
C		Q	
D	Departmental	R	
E		(S	Stores and supplies)
F		T	
G		U	
H		V	
J		W	
K		X	
L		Y	Fixtures and sprinkler system
M	Merchandise	Z	Land and buildings

Subdividing now our main base sheet, let us see what the classification will be in a typical, moderate-sized department store. The auxiliary expenses will be listed and symbolized as follows:

AA[1]	Advertising	AN	Information bureau and Post Office
AC	Cash System	AP	Shipping department
AE	Elevators	AR	Receiving department
AF	Telephone and Telegraph	AS	Supply department
AH	Heat, light, and power not elsewhere classified	AT	Transportation
AJ	Janitor service	AW	Waiting room
AK	Stockroom	AZ	Land and buildings: repairs, maintenance and rent.
AL	Alterations and repairs		
AM	Employment		

[1] In practice in making up a classification, it is desirable invariably to put down all the letters of the alphabet, omitting "I" and "O." Letters not used are omitted here and elsewhere in this article from considerations of space.

The base sheet for administrative expense will be this:

BA Accounting department	BN Insurance
BE Educational department	BP Protection
BF Floor-walkers	BS Statistical department
BG General offices	BV Inventories
BH Shopping	BX Taxes
BL Legal expenses	BY System expenses
BM Mail order department	

D is the general symbol for departmental expense and, where there are but few departments, a letter may be added after the D to symbolize the department: for instance, in a shoe store that is divided into men's, women's, infants', and hosiery departments, these will be designated as DM, DW, DN (I and O are omitted from this symbolic system on account of their resemblance to the figures 1 and 0), and DH, respectively. In a department store this is not practicable without classifying and symbolizing the departments with a resultant symbol of two or three letters for each one. In order, therefore, to keep the symbols short, it is better to number the departments; and this number should be inserted immediately after the D. In the following base sheet for departmental expenses, the dash after the D is for the symbol or number of the department:

D–A Advertising for special departments	D–H Handling cash and goods
D–B Buying	D–K Marking
D–C Repairs and maintenance	D–L Alterations
D–E Equipment	D–S Selling
	D–T Transportation

It will be noted that in the original base sheet, S is included in parentheses, as is also M; this is for the purpose of reserving these symbols for materials constituting stores and supplies and for merchandise.

The classifications of fixtures and of land and buildings are simple and obvious and, as they do not enter into our expense account, except as to depreciation which is otherwise charged, their base sheets are not given here.

A few typical base sheets for detailed classes of expenditure may be given as guides to the development of a complete classification — for instance:

AA — *Advertising*

AAA	Salaries and wages, except window-dressers	AAN	Newspapers { AA1N, AA2N, AA3N }
AAB	Bill-boards	AAP	Programs
AAC	Contributions	AAR	Reclamation of errors
AAF	Telephone (toll) and telegraph	AAS	Supplies and stationery, except for window-dressing
AAG	Catalogues	AAV	Advertising mediums not elsewhere classified
AAJ	Dodgers	AAW	Window-dressing
AAL	Circular letters		
AAM	Magazines		

Under AAN, you will notice AA1N, AA2N, etc. These are the symbols for the specific newspapers advertised in.

You will also notice an account, AAR, reclamation of errors. This is for such charges as arise out of mistakes made by the advertising department of which it is desirable to keep a separate account. The same application should be made to the work of every department.

AAW, Window-dressing, may be subdivided thus:

AAWA	Salaries and wages	AAWR	Reclamation of errors
AAWC	Repairs and maintenance	AAWS	Supplies and stationery
AAWE	Equipment		

An important classification in some stores will be that of AH, heat, light and power not elsewhere classified. It will cover the following items:

AHA	Salaries and wages	AHE	Equipment
AHB	Repairs and maintenance for boilers, engines, and other machinery, not elsewhere classified	AHF	Fuel
AHC	Repairs and maintenance for fixtures and furniture, not elsewhere classified	AHL	Electricity
		AHP	Repairs and maintenance for piping, fixtures, and wiring
		AHS	Stores and supplies and stationery

Alterations and repairs should have an account of their own, for which we would use this base sheet:

ALA	Salaries and wages	ALR	Reclamation of errors
ALC	Repairs and maintenance	ALS	Supplies and stationery not elsewhere classified
ALE	Equipment		
ALM	Materials		

Alterations and repairs and rent for land and buildings are symbolized respectively AZC and AZR.

General office expenses, which may amount to a considerable item, may be grouped in this way:

BGA Salaries and wages
BGB Books and periodicals
BGC Repairs and maintenance
BGD Dues and assessments in associations
BGE Equipment
BGF Telephone (tolls) and telegrams
BGN Entertainment
BGS Supplies and stationery
BGT Traveling

Insurance is taken care of as follows:

BNB Bonds
BNC Repairs and maintenance of sprinkler system
BNL Liability
BNS Stock and fixtures

Buying expenses are sometimes important and heavy. They should be grouped in accordance with the following base sheet:

D-BA Salaries and wages
D-BB Bonuses
D-BC Commissions
D-BE Extra premiums
D-BF Telephone tolls and telegrams
D-BN Entertainment
D-BR Reclamation of errors
D-BS Supplies and stationery
D-BT Traveling
D-BX Loss on sales (markdowns)

This buying expense classification is based upon a fairly highly developed organization in which it is possible easily to segregate most of the expenses. It can be applied to smaller organizations, however, by a reasonable apportionment of expenses between the classifications concerned. For instance, if the same individual is engaged in both buying and selling, it ought not to be difficult to charge part of his salary to one, and part to the other. Do not be misled into thinking there are no buying expenses because you may not happen to have buyers so-called; nor, on the other hand, into thinking that all the expenses of a buyer, and especially in a department store, are buying expenses. If a manager in a small store sells goods, keeps the accounts, and does the buying, part of his salary should be charged to buying, even though he performs that function nights and Sundays. On the other hand, in a department store where the buyer is the head of the department and may also do some selling, care should be taken to charge to buying expenses only that part of his time which is actually occupied in buying. This calls for the exercise of judgment and cannot be absolutely accurate, but it can easily be made accurate enough for ordinary purposes.

The degree of minuteness to which this classification will be carried will vary of course with the relative importance of the department or function under consideration. For instance, if the mail order department is a considerable part of the business, it will have a complete classification of expenses of its own; while if it is distinctly subsidiary, a much rougher and less complete classification will serve.

In the apportionment to each function of a business of such items as supplies, it becomes necessary to organize a supply department, from which supplies are issued to other departments on requisition, which may be charged directly against the department receiving them. Here again successful factory experience has been easily transplanted to department store work. The best way of handling this is to gather the supplies and stationery into a storeroom, make it some one's business to act as storekeeper, and classify and otherwise handle the supplies as described in my former article, "Listing Stock to Index Wastes," on page 490.

If the store under consideration is a one department or unit concern, there is no problem of apportionment of indirect expense, and the items of expenditure may be grouped easily in accordance with the symbol to get any totals desired. If you want to know, for instance, your total expenditures for freight, express and cartage, all you have to do is to total all the AT items. If you want to segregate the expense of delivery companies, freight, messengers, and parcels post, simply re-divide into ATD, ATF, ATM, and ATP, respectively. If, on the other hand, you want to get the total cost of handling goods and customers, that is, the auxiliary expenses, total all the A's; or if you want your total administrative expenses, take the sum of all the B's. The entire indirect cost of your alterations and repairs is simply the total of the AL items. Your buying expense is the sum of DB for all departments, that is, it will include DBA, DBB, DBC, DBE, DBF, DBN, DBR, DBS, DBT, and DBX (if the loss on sales is charged against buying). Similarly, all your advertising expense is easily closed into a control account AA, composed of all those items the symbol for which includes AA as its first two letters.

All this means that every expense should have a voucher, to which the proper symbol is affixed; but if this is done, the resultant ease of handling is what makes the system worth while.

If, however, the store in question is organized in two or more departments, it becomes highly desirable to apportion the indirect expense in some fair way over departments. Such an apportionment properly made often shows wide variations in the profits from different departments, and may even reverse the current opinion of the management as to their relative money-making capacity. This becomes a highly important practical question as it is nothing unusual to find the profits of one department eaten up by the losses of another. This may sometimes be tolerated as a permanent condition where the maintenance of the loss-producing department is desired as an advertising feature or as a convenience to customers; but even in that case the management should be in a position to know what this advertising and convenience are costing it.

The problem of apportioning indirect expenses over departments is not difficult if sufficient thought is given it in advance, and the method of apportionment indicated in the symbol for the expense. This is another story, however, and will be discussed fully in the next section.

II

Making Departments Pay Their Share

The first and great commandment in scientific management is accurate determination of facts. In its application to cost accounting this means that all the items of expense shall be carefully analyzed and re-grouped, so that each separate item may be charged to its appropriate group and thus the management kept informed as to the general tendency and location of its expenditures. For the business to succeed the management must get back all that it puts in, plus a profit. If it is at all departmentalized, the management must see that each department or group of products gets back all that goes into it. There is no way of being sure of this unless all the costs, indirect as well as direct, are properly charged against each department or group of products, and unless returns from sales are so analyzed as to show the returns of each department or group. The problem of allocating every item of expense to the group or department to which it belongs is by no means a simple one, and in current factory practice it has called for and secured the highest grade of ability and attention. Every up-to-date factory has a cost accounting system which in practically every case is admittedly complex and elaborate. Many factories, however, have progressed to the point where complexity and elaborateness are no longer adverse criticisms, provided they are no greater than is necessary to secure the accurate information demanded.

That the science of management of retail stores, as compared with that of scientifically managed factories, is still a mere infant hardly able to walk is nowhere more strikingly shown than in the current methods of charging departments with their share of the indirect expenses of the store. In factories the subject of costs has long since been worked out to a high degree of refinement. Every factory cost accountant is familiar with at least half a dozen methods of distributing indirect expenses, and every expert can say with confidence which method should be used in particular instances and for particular departments. There are several books on factory costing which are really scientific pieces of work; but for department stores there is nothing. In the struggle to develop advertising and merchandising always a step beyond what the competitor is doing, the details of store administration have had but scant attention. It is as though the army spent all its time at rifle practice and never considered the commissary, transportation and sanitary provisions without which, with all its fighting efficiency, it would be utterly useless in time of war.

As pointed out in the last section in this series, it is highly important that a department store should know what share of its indirect expenses should be charged against each department. In the absence of such information it is not at all unusual to find a department, supposed to be making a profit, actually running at a loss. In fact, instances have been known where the manager would relieve a weak department of any proper share of expense in order to have that department show a profit, with the explanation that he was n't going to have a department that didn't show a profit. That is the policy of our old friend, the ostrich. This policy is not altogether unknown even now in factories, but the factory in which it is found is sure to be spoken of as old-fashioned.

The modern policy is to find out exactly what each department really costs, not only in the amount of merchandise handled through it, but in supervision, accounting, floor-walking, elevator service, general advertising, and the other innumerable features which go to make up the entire expense of a store but which cannot be charged directly against a department. This is the problem of apportionment — to take all those costs which are incurred by the store as a whole and distribute them over the store components as justly as possible.

Some of the more progressive stores have already accepted the principle of the apportionment of expenses over departments; but as a rule their methods of apportionment are, to say the least, crude. It is quite usual to find all the expenses apportioned by the amount of sales. That this is not at all accurate should be evident on brief consideration. A department selling notions, for instance, may have three times the number of employees, making its cost of supervision greater, and twenty times as much clerical work as the rug and carpet department or the musical instrument department, while its total volume of sales may be less. In this case the rug department would be charged with considerably more than its proper share of the clerical expense and supervision. On the other hand, the rug and carpet department may occupy three times the space of a jewelry department doing as much business. If, as has happened, rent is distributed on the basis of total volume of sales, the jewelry department will be paying a large part of the rent which the rug department ought to be charged with. The condition is just as bad when indirect expenses are apportioned entirely on the basis of floor space occupied. When this is done, the rug department bears part of the burden which ought to be carried by those departments occupying a small floor space.

There is in fact no one method of apportionment which is either logical or even approximately accurate. If accuracy is essential — and as competition becomes keener, reasonable accuracy becomes indispensable — the apportionment of indirect expenses should be on the basis of the actual facts; and on this basis there will be at least ten or fifteen different methods of apportionment for different items of expense.

There are certain items of expense for which it is easy to find the proper method of distribution. Take the cash system, for example, consisting of a number of stations of carriers, a group of cash girls, and the necessary printed forms. The expenses involved are wages, repairs and maintenance, small equipment, power, rent (unless the system is owned by the concern), and incidental supplies. According to the cost classification illustrated in the last section, this will be symbolized as follows:

AC — *Cash System*

ACA	Wages and salaries	ACP	Power
ACC	Repairs and maintenance	ACR	Rent
ACE	Equipment	ACS	Supplies

When these systems are rented, it is at a charge of so much per station. It is fairly obvious, therefore, that the rent should be distributed over departments in proportion to the number of stations in departments. It is clear also that the cost of repairs and maintenance, equipment, supplies, and power is proportionate to the number of stations and should, therefore, be distributed in the same way. On the other hand, wages of girls in the central station are not necessarily proportionate to the number of stations in departments, but rather to the number of sales in departments, and should therefore be distributed on the basis of the number of sales slips. In any case these items are in no way proportional to the total volume of sales or the amount of floor space occupied.

That part of the work of the accounting department which does not deal with purchasing or stockhandling of merchandise, is concerned in the main with daily sales, credits, and monthly bills. The expense of those clerks dealing with sales and credits should most reasonably be distributed over departments in proportion to the number of sales slips as representing most accurately the number of sales, while that of the billing clerks should, of course, be distributed in proportion to the number of bills entered.

There are facilities provided by a store, such as the information bureau, post-office, and waiting-room, the expense of which should be apportioned according to the number of people using them. In other words, they should be distributed over the departments in proportion to the number of people making purchases in the department; and this is evidenced by the number of sales slips. The benefit that the firm derives from an education department if it maintains one, is also proportional to the number of sales made; and this expense should therefore be apportioned on the basis of sales slips.

Take such an item as telephone and telegraph expense. When this is incurred in connection with buying for a department, obviously it should be charged directly against the department buying. There are many telephone and telegraph charges, however, which are not incurred directly by a department but should in some way be distributed. Evidently there is no connection between the telephone calls and the volume of business or the floor space occupied by departments. An easy and sufficiently accurate method is to distribute them in proportion to the average number of calls directly charged against departments.

There are many kinds of expense which should be distributed on the basis of the number of square feet occupied by departments. Rent, for instance, is clearly on this basis. Heat, light, ventilation and power, not already charged directly to a department, should be apportioned on the same basis. Janitor service also is generally in proportion to square feet of floor space. The same is true of the repairs and maintenance of sprinkler system. Where floor-walkers have a round that includes more than one department, their cost should be distributed also on the number of square feet.

There are many other bases of apportionment, each of which has its own particular application. If a stockroom for supplies is maintained, the expense of this stockroom should be distributed in proportion to the value of supplies used by each department. Insurance on stock should be spread over the average stock carried by departments. The cost of window-dressing should be charged in proportion to window space occupied by each department. Advertising is usually to be charged directly against the department advertised; but in all advertising there is a large element which is general: that is, which advertises the store as a whole and from which each department gets some indeterminate share of benefit. Bill-boards, contributions to charity, etc., fall into this class. General advertising in newspapers should be distributed over departments in proportion to the total advertising space taken by the department during the year. This applies only to such general advertising as appears in newspapers. Other general advertising cannot be distributed in any way proportionately to the benefit derived by a department, for the reason that such proportionate benefit cannot be ascertained. The disposition of this expense will be discussed later in this article. Delivery expenses, to be accurate, should be distributed in accordance with the number of parcels shipped from each department. The expense of an employment bureau and liability insurance should be charged on the basis of the department payroll, as these obviously vary with the number of persons employed and their wages or salaries.

The elevator expense offers a special problem. It is not exactly fair to distribute it over the entire store in proportion to the number of people using a department, nor on the basis of floor space, for departments on the street floor have no use for the elevator at all, and, therefore, should not be charged with any part of the elevator expense. The best plan seems to be to distribute it in proportion to the number of sales in the basement and second and upper floor departments.

If the concern does a small mail order business, not sufficient to warrant a separate mail order department to which the cost may be charged directly, the expense of its mail orders should, of course, be distributed in proportion to the mail orders filled by departments.

There remain quite a number of expenses which cannot be allocated logically on any of the bases stated. For instance, general advertising not in newspapers, general office expenses, stockroom expense, shipping and receiving department cost, general transportation charges, legal, protective, statistical, "shopping," and system expenses, — this means of course all expenses falling in these groups which cannot be charged at once and directly against departments. Something might be said for distributing these in proportion to the total sales of a department but, as the total sales basis is such an easy one to abuse, it is preferable to eliminate it altogether. These general expenses might with at least equal justice be distributed equally to departments and, as they are the only ones that can be so distributed with any logic whatever, that method is to be preferred as the danger of abuse is less.

We thus have fourteen bases of distribution of expenses:

1. Number of square feet.
2. Advertising space taken by department.
3. Window space occupied.
4. Number of sales slips.
5. Number of bills entered for departments.
6. Number of sales in basement, second and upper floors.
7. Number of parcels delivered.
8. Number of mail orders filled by departments.
9. Average stock.
10. Number of carrier stations.
11. Value of supplies used by department.
12. Average number of calls for departments.
13. Payroll.
14. Equally to departments.

The administration of this system is not so difficult as might appear on the surface, if it is thoroughly and carefully worked out in advance. Distribution by departments calls, of course, for a definite determination of the number of departments involved.

Distribution by number of sales slips involves totalling the number of sales slips from each department each day for each week, if the distribution is to be made weekly. Apportionment by number of square feet means measuring the area of each department and getting its proportion to the total "productive" area of the store (meaning by "productive" such space as is actually used by selling departments).[1] Bookkeepers' expense to be determined according to the number of bills entered for the departments, requires a weekly total of this number; similarly with distribution by number of mail orders and average number of telephone calls. Apportionment by value of supplies used requires that supplies issued to the department shall be issued on requisition, with the values noted on requisition and totalled at the end of the week. Advertising space and window space occupied must be measured. Payroll and average stock are already available for the management. The number of stations of the carrier system is easily ascertained. The number of parcels delivered must be kept track of by departments.

With these data once secured, any good clerk with the aid of a calculating machine or a slide rule can make the necessary distribution very quickly, if only she knows how each item is to be distributed. That is taken care of very simply by numbering the methods of distribution, as in the list above, and inserting the number in the cost symbol on each voucher, the symbol being determined as described in the previous article.

For this purpose the cost symbols for specific items should be written with a space between the first and second letters, this space being filled in with the number of the distribution method. On this basis the cost symbols for the accounting department will be as follows:

B-A — *Accounting Department*

B-AA	Salaries and wages	B4AR	Reclamation of errors
B4AC	Repairs and maintenance	B4AS	Supplies and stationery
B4AE	Equipment		

[1] It should be distinctly understood that productive and unproductive in this sense are accounting terms and do not mean at all that space used for a stockroom, for example, is unproductive, but merely that this expense cannot be charged directly against a department but must be distributed on some basis over all departments.

Salaries and wages distributed differently must have a different base sheet:

B-AA — *Salaries and Wages*

B4AAA Auditors
B5AAB Bookkeepers
B4AAC Cashiers

If every payroll voucher in the accounting department has the symbol stamped on it, every one marked " B4AA " will be distributed on the basis of the number of sales slips; while "B5AAB" will be on the basis of the number of bills entered. The application of this to the rest of the system can be easily made.

It would be vain to pretend that this system of apportionment is a family necessity. It is not intended for the small, single-line store. It is meant only for department stores or for stores organized departmentally. For them some system of apportionment is a necessity, and the justification of this particular one is that it comes considerably closer to accuracy than any of the methods now in common use in department stores. It is for them a necessity because, without it, they cannot know accurately the percentage of profit or loss they are making on departments; without it they have no accurate guide to changes in buying, selling and advertising policy; without it they cannot make an intelligent mark-up, nor can they know accurately the cost of markdown; and it is daily becoming more and more true that, without such a system, they cannot meet permanently the increasing competition of ambitious newcomers in retailing. With such a system intelligently administered they can do all these things.

III

A Stockhandling System for Merchandise

A scientifically managed factory operates on the basis of definite and accurate knowledge of every detail necessary to the successful prosecution of its business. It makes its product out of raw materials. It knows what raw materials it has ordered, from whom, and when they are to be delivered; it knows the quantity on hand in its storerooms and its cost. It knows how much its current manufacturing orders call for and, therefore, how much of the quantity on hand or on order is reserved for specific orders. It has determined on the basis of current and prospective use just how low it can allow its stock to fall without interfering with production, and how high it can allow it to go without tying up too much capital; and it provides for automatically ordering within these limits.

The factory is so careful about its stores system because the productive process originates there. The product cannot be made or even started in the works unless the raw materials are on hand. The scientifically managed factory is equally careful of the material after it has started on its course. In the first place it charts that course in advance; then it sees that material is guided through it without deviation; and it keeps track all the time of the location of the partly finished product on its course, until it arrives finally in the stockroom, and is shipped to the customer. This constant keeping tabs on the material is not an easy thing to do and has had to justify itself by its results. What it accomplishes is this: first, standardization of materials by elimination of those not necessary or not best adapted; second, reduction of the amount of capital tied up in raw materials; third, a guarantee that raw materials are on hand when needed; fourth, accurate knowledge of the progress of the product through the shop, enabling reasonable promise dates to be given; fifth, control of the finished stock, making prompter shipments possible. This last result, delivery to the customer, is the end and aim of the manufacturing process.

Delivery to the customer is also the end and sum of the retailing process. In order to insure it, the goods to be delivered must have been ordered, received, transferred to the shelves, and finally delivered. They must be on hand when the customer wants to see them; there must not be so much stock that capital is unnecessarily tied up. The chief and practically the only difference between the requirements for the proper accounting of materials in a factory and in a store lies in the fact that the interval between the receipt of raw materials and the delivery of the product in the factory is longer and includes manufacturing processes, whereas in the store it consists merely in the transfer from the storeroom to the shelves and, in some cases, even that is lacking. The methods of accounting, therefore, which have been found successful in factories should be even more successful and simpler in stores; and this article describes an application of a factory system to merchandising.

Every properly-managed store gets frequent reports of the total sales of merchandise each day. These reports are usually in the form of totals for departments in a department store or for entire lines of goods in other stores, such as men's shoes, women's shoes, or cloaks, dresses, and piece goods. The report usually shows also the value of goods unsold and such incidentals as discounts, returns, and repairs and alterations. On the basis of these detailed reports it is possible for the manager to check up the condition of store or department and to keep in constant touch with its needs. If the department is doing well, no action is necessary; if it is not keeping up to the standard set, the buyer is jacked up and the necessary steps taken. These daily records extended over a period of years are sometimes charted by weeks or months, or even daily, and the resultant graphs are used to predict the probable demand.

Such information when secured for the store or the department as a whole has some value, but its usefulness is slight compared with that to be derived from similar information by lines or classes of goods. The most up-to-date stores are using the latter method, and still further subdivide their information by prices; and the result of this analysis is to show what priced goods sell best. Some curious information has been derived by this means. It has been shown pretty conclusively, for instance, that a glove will sell for $1.25 more quickly than if it is marked $1.15; and that a $2.00 glove sells better than one at $1.75, although the quality is the same or inferior.

The greatly increased value of the result when the analysis is by lines and prices raises the presumption that a still more minute analysis will be even more worth while.

No up-to-date factory follows the current methods of stores in the handling of its stock. The reports of a factory on raw materials and stock on hand are totaled only when an inventory is wanted. Each article carried has its own stock ledger or balance sheet, and the management may know at any moment precisely the quantity and value of each item in stores, in process, or in stock; and with such detailed information before it, it can control its purchases, the routing of its materials, and its investment of capital with the utmost effectiveness.

There is apparently no reason other than custom why retail stores should not follow the same procedure. There should be no more excuse for over-time work or even closing down for stock taking in a store than in a factory; and the most progressive factories have ceased to interrupt their business for inventory. The value of a perpetual inventory is so well known and so generally acknowledged that no argument should be needed in its support.

And there is a far stronger reason why a store should know exactly and in detail how each item it carries is selling than that a factory should know how its raw materials are going. In general the success of a store depends upon the rapidity of its turn-over, assuming of course that each turn-over is at a profit. Rapid turn-over means a comparatively small investment of capital and great elasticity in stock. In stores carrying seasonable goods or goods strongly affected by changes in fashion, frequent turn-over is absolutely necessary to keep the stock up to date and prevent loss through rapid obsolescence.

It usually happens that the advantages of rapid turn-over vary with different items. In the first place where the profit is large, the turn-over need not be so rapid as in those cases where the margin is small. In the second place, in any given line of goods, such as dress goods for example, certain materials are staple and the fashion in them does not change frequently; while others are in to-day and out to-morrow. Here a quick turn-over is essential. Obviously a report which totals results from all these types of merchandise gives a mere average composite picture which is true neither of the staples nor the novelties, nor of the big profit and small profit items.

In this matter, as so frequently in business, ultimate success depends upon attention to detail, which means again analysis and classification.

Frequently the steps necessary to be taken to secure such detailed analysis are not difficult. The totals now given the manager presuppose items from which the totals are built up. In order to make the system complete, all that is necessary is that each of these items shall be carried on a merchandise ledger or balance sheet of its own. This does not involve much more clerical work than is now already undertaken. When this is done, the balances shown for each item can be easily combined by classes in such groups as are similar from any point of view in which the management is interested: for instance, by price ranges, by rate of depreciation, as staples, novelties, etc. With such detailed reports before them, the manager and the buyer cannot help but be more intelligently guided in their decisions. In addition such an accounting provides a perpetual inventory of the store.

The detail of the method to be followed is illustrated in the forms reproduced herewith. These forms may be combined on one sheet and kept by merchandise clerks in the accounting department; this takes away practically all clerical work from stock keepers, salespeople, and buyers, and concentrates it in the clerical department where it belongs. Experience has shown this to be the best method in factories where the system is working most successfully. If for any reason, however, this arrangement is not desirable, the forms may be separated and columns 1 and 4 kept in the accounting department and columns 2 and 3 in the stockroom. The description of their use will assume that they are kept together in the accounting department, and will be based on the practice of a department store. Modifications to meet other conditions may readily be made.

Each sheet is the account for each item carried in stock; for example, boy's two-piece suit, blue, No. 531 — the sheet may be subdivided by ruling clear across it horizontally to provide a section for each size.

Column 1 shows the materials ordered but not yet received. It is made up from a copy of the purchase order which comes from the buyer, after being O. K.'d or confirmed by the proper authority, and shows the date ordered, date received, purchase order number, quantity ordered, billed cost, discount, and net cost. It is not necessary to enter on this sheet the name of the source of supply as that is not essential to the account. If for any reason it is wanted, it can easily be found by reference to the copy of the purchase order filed numerically. It may be desirable to know whether the order is placed with a jobber or a manufacturer. For this purpose a J or an M may be entered after the order number.

Column 2 shows the quantity and total cost of the item received in the stockroom (which in the case of a small store is the store itself). Its sub-columns have date received, quantity, purchase order number, delivery charges, total cost (which is the net cost plus the delivery charges), by simple division the cost per unit, and the quantity still due upon order in case of partial shipment.

By comparing columns 1 and 2, it is easy to see which orders are delayed in shipment and need tickling, and the balance still to be delivered. Column 2 shows the cost per unit, which is the basis of the mark-up.

Column 3 is intended to show mainly the merchandise on hand in the stockroom and its price. This column is obviously not needed in a store where goods are placed directly on the shelves without going through a stockroom. It is got simply by deducting the quantity issued to the department or to the shelves from the total quantity received in column 2 and entering the balance in the column, " Balance on hand," in column 3. Column 3 provides for the date of issue from the department to the shelves, the quantity issued, the requisition number on which the issue is made, the price per unit (which is the total cost from column 2 plus the mark-up), the total price of the issue to the department. and the balance on hand secured as just described. It is the business of the stock-keeper to call the attention of the buyer whenever the balance on hand falls to a predetermined minimum. The buyer will then decide whether to re-order. The minimum limit should be so set that, if it is desired to re-order, there will be enough goods still on hand to meet customers' requirements until the new shipment is received. This depends therefore upon the rapidity with which goods are being sold and upon the probable length of time between order and shipment. To set this minimum limit calls for the exercise of considerable judgment; and in general it should err on the side of too much rather than too little, if it is the policy of the store always to meet its customers' needs.

Column 4 is the account of actual sales in the department. It shows first the date received from the stockroom, the quantity, requisition number; and these three sub-columns should check with similar sub-columns in column 3. Column 4 shows daily the quantity sold net, the total price of this quantity, the quantity sold at a discount, the rate of discount, and the total net price of such discount sales, together with the total of all sales. Finally, by deducting the sum of the quantity sold net and the quantity sold at a discount from the total quantity received, column 4 shows the quantity still on hand in the department. When the quantity on hand falls to a predetermined minimum, the responsible person in the department requisitions the stockroom for more goods. This requisition must of course go first through the balance clerk in the accounting department to see that the goods are in stock, and if they are, to make the necessary entries debiting the requisitioning department.

The items in column 1 are made up from a copy of the purchase order, those in column 2 from the stock-keeper's report of quantity received and the vouchers for delivery charges, column 3 is derived from the department requisitions, and column 4 from the daily sales slips. The system is thus very simple and easy to administer. In case more checks are desired on the quantity and quality of goods received, further detail may be developed for the purpose. The extent to which this is done will depend upon the size and other conditions of each individual concern.

At the head of each balance sheet must be entered the following items of information: a description of the article, the kind of unit, the minimum of merchandise in the stockroom at which point the balance clerk is to notify the buyer, the minimum of merchandise in the department or on the shelves at which point the department head is to notify the stock-keeper, and the location of the item in the stockroom and on the floor. The minimum on hand in the department at which point a further requisition is to be issued is kept by the balance clerk as a check on the department head. The latter must, of course, be supplied also with the same minimum.

It is advisable to print at the head of the sheet a summary of the instructions for posting, as it will be found in practice that it takes balance clerks of average intelligence a month or more to get the balances in shape and keep them there. It must also be remembered that no balance sheet can remain accurate very long without frequent checking, at first by actual count of the quantities on hand in the stockroom and in the department. For a while it will be advisable to check every sheet as often as possible, even if this necessitates double the force of clerks for a month or two. After that the sheets may be divided into groups in such quantities that the entire stock will be covered say once in three months, by checking one group each day.

For convenience of filing, brevity in writing, and definite identification of each item (which in practice often goes by a variety of names), it is usually desirable to symbolize each item. The method of mnemonic symbolization, which I believe to be the best for general purposes, was described fully in a section on " Listing Stock to Index Wastes " on page 490. It may be interesting to illustrate how this works out in practice. " M " is the first letter in the symbol for " Merchandise." In a department store this would be followed by a " D " for department, with the number of the department between the " M " and the " D." It is advisable to number departments where there are many of them rather than attempt to give them mnemonic symbols. In a one-line store the hyphen and the " D " are omitted and the symbol for the class of articles to be symbolized falls immediately after the " M " unless there are several items of the same article but with different dimensions, in which case the distinguishing dimensions are included after the " M."

Suppose we start with our original cost base sheet (see page 485):

A	Auxiliary expense	P	
B	Administrative expense	R	
C		(S	Stores and supplies)
D	Departmental expense	T	
E		U	
F		V	
G		W	
H		X	
J		Y	Fixtures, machinery and equipment, except that which is written off when purchased.
K			
L			
(M	Merchandise)	Z	Land and buildings
N			

Suppose the kitchen ware department is No. 2. The base sheet for it will be somewhat as follows:

M2DA	Aluminum	M2DN	Nickel ware
M2DC	Chinaware	M2DP	Copper ware
M2DD	Seeds, bulbs, shrubbery	M2DR	Rubber goods
M2DE	Earthernware	M2DS	Steel and iron ware
M2DF	Filbrous ware	M2DT	Tinware
M2DG	Glassware	M2DV	Stoves
M2DH	Hardware	M2DW	Wooden ware
M2DK	Crockery	M2DX	Miscellaneous, not elsewhere classified
M2DL	Lighting fixtures		
M2DM	Enamel and agate ware		

The base sheet for chinaware will be this:

M2D–CA	Plates	M2D–CP	Pitchers
M2D–CB	Bowls	M2D–CS	Saucers
M2D–CC	Cups	M2D–CT	Platters
M2D–CD	Sauce dishes		

Plates, bowls, etc., will have their dimensions inserted where the hypen appears after the "D."

For a grocery store or grocery department, the following base sheet will usually be found sufficient:

M7DB	Beverages	M7DD	Dairy products, not elsewhere classified
M7DC	Cereals and cereal products	M7DE	Extracts, syrups and colorings

M7DG	Gelatine, baking powder, and other cooking compounds, not elsewhere classified	M7DM	Meats and fish, not perishable
M7DH	Herbs, seasonings, condiments, and spices, not elsewhere classified	M7DP	Pickles, olives, olive oil
		M7DS	Soaps, cleansers, polishers
		M7DU	Fruits and nuts, not perishable
		M7DV	Vegetables, not perishable
		M7DX	Miscellaneous

If this department carries fresh vegetables, they might be put down under M7DF; fresh meats under M7DT.

The following subdivisions will illustrate the subject further:

M7DBD Dry Beverages
M7DBW Wet, except milk and cream (for which see dairy products)

Dry beverages will be further subdivided, as for example:

M7DBDB	Bouillon cubes	M7DBDK	Cocoa
M7DBDC	Coffee	M7DBDM	Malted milk
M7DBDD	Drugs	M7DBDT	Tea
M7DBDH	Chocolate		

And the different brands of cocoa, for instance, may be designated thus:

M7DBD1K	Baker's cocoa	M7DBD4K	Trinity cocoa
M7DBD2K	Lowney's cocoa	M7DBD5K	Runkel's cocoa
M7DBD3K	Van Houten's cocoa		

Where there are different sizes or weights for the same article, they may be indicated as follows:

M7D¼B1W	Grape juice, 4 oz.	M7D1B1W	Grape juice, 1 pt.
M7D½B1W	" " ½ pt.	M7D2B1W	" " 1 qt.

Department No. 8, handling supplies and stationery, would have its goods classified in this way:

M8DA	Blank cards	M8DP	Pens, penholders, and pencils
M8DB	Blotting papers	M8DR	Ribbons, typewriter, and adding machine
M8DC	Chairs	M8DS	Paste
M8DD	Desks	M8DT	Tables
M8DE	Erasers	M8DU	Rubber bands
M8DF	Files and filing cabinets	M8DW	Writing paper, unprinted
M8DH	Card holders		
M8DK	Inks		
M8DN	Blank books		

It may be interesting to set out in detail the classification of stock for a shoe department, which for convenience we will call Department 10. The base sheet will be :

M10D-A Athletic	M10D-S Special
M10D-M Men's	M10D-W Women's
M10D-N Infants'	

M10D-M, Men's Shoes, is subdivided:

M10D-M-H High	M10D-M-L Low

Further subdividing Men's High Shoes, we have the following:

M10D-M-HC Cloth	M10D-M-HR Rubber
M10D-M-HF Calf	M10D-M-HS Substitutes
M10D-M-HK Kid	M10D-M-HV Vici
M10D-M-HP Patent	

Men's High, Calf Shoes would be subdivided as follows:

M10D-M-HFB Blucher	M10D-M-HFS Straight lace
M10D-M-HFC Congress	M10D-M-HFT Button

Each shoe is built on a last peculiar to itself and has a size, width, and color. The last number should be filled in where the hyphen appears after the "D"; the size and width after the "M," and the color should come last. If the last number includes a letter, the combination should be put entirely in parentheses, in order not to confuse the letter with the rest of the symbol, as should also the size and width. If, for instance, the shoe to be symbolized is a Kelwain, last No. 297, size 9, width B, and light tan, in a men's calf blucher, the symbol would be:

M10D(K297)M(9B)HFB1T

T meaning tan, and 1 light tan; medium tan will be 2T; dark tan 3T, etc.

Any system of stockhandling which is more complex and cumbersome than those now in use would hardly be justified, unless there is a great deal to commend it. Fortunately the system described in this article is far *less* complicated and cumbersome than the usual methods, except in those stores which have no method at all. The number of forms required for its efficient operation is small. The amount of clerical work involved is not as great as is usually found in the ordinary systems. The result, when this system is properly administered, is a complete, accurate and up-to-date account of the precise condition of the stock on hand, from which it is easy to deduce the present and probable future demand for each item carried. When the salesman comes in and you want to know what to re-order, and in what quantities, you can get your answer at once from an inspection of the merchandise sheet for your department or store, without going outside the office for it. When you want to know the total value of all stock on hand all you have to do is to total the values given on these sheets, and there is no necessity for losing three days' trade to take an inventory.

In view of the fact that this entire system is administered more cheaply and easily than any other system that comes even anywhere near giving the same results, the apparent complexity of the balance sheet itself should not be allowed to have any deterrent effect on the manager who wants to be in a position to meet competition by knowing exactly what he is doing, rather than by guessing at it.

SCIENTIFIC MANAGEMENT IN THE OPERATION OF RAILROADS

BY WILLIAM J. CUNNINGHAM

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THE most striking feature of the recent public hearings before the Interstate Commerce Commission, in the matter of proposed increases in freight rates, was the charge of railroad inefficiency. Mr. Brandeis's clever turn in attacking the railroads in the quarter where attack was least expected called sharp attention to the subject of railroad management. The public was caught instantly by the dramatic statement that the railroads could save a million dollars a day through the adoption of a new system of scientific management, and their lively interest in it was kept up by newspaper and magazine discussion. In getting at the truth, the public had little constructive assistance from the railroads, and their disdainful attitude added to the first effect of the charges. The general impression, therefore, was that the railroads were needlessly deficient.

It is advisable to examine the charge of inefficiency apart from the rate question, which is now settled.[1] It is, perhaps, comprehensible that the railroads, already harried by public attack

[1] In its decision of February 22, 1911, on proposed advances of rates by carriers on official classification territory, the Commission says: " It is difficult to see exactly what application the Commission can make in this case of this testimony [on scientific management]. The witness who apparently had most to do with originating and applying these methods testified that they were in actual operation in not over one-tenth of one per cent of all the manufacturing establishments of this country. The system is everywhere in an experimental stage. To some extent it has been tried and is now being tried by our railways. The representatives of railway labor who appeared before us stated that these methods could not and should not be introduced into railway work. Upon this record, we can hardly find that these methods could be introduced into railroad operations to any considerable extent, much less can we determine the definite amount of saving which could be made. We cannot therefore find that these defendants could make good any part of these actual advances in wages by the introduction of scientific management."

and suspicion, and now reproached unjustifiably, as they think, should be indignant at being presented with a new pill to swallow. Perhaps they may be pardoned for looking on it as a quack remedy. But it behooves the student of railway problems to examine the new prescription carefully and, so far as may be, impartially to inquire whether the railroads have some justification for distrust, to ascertain if the extent of waste is as great as suggested, to indicate some of the limitations on the adoption of any system of scientific management, and to suggest what may be learned with profit from its advocates.

It is necessary at the outset that we have a clear understanding as to what is meant by scientific management. To obtain it, we will go at once to headquarters. Mr. Frederick W. Taylor, consulting engineer, Philadelphia, is acknowledged as the dean of the efficiency experts and the originator of the new system. Mr. Taylor was conspicuously successful in his management of the Midvale Steel Company, where he was successively laborer, foreman, superintendent, and general manager. There his system was first worked out. In addition, he has also made an international reputation as the inventor of high-speed steel for metal-cutting tools and drills, an achievement in itself sufficient to stamp him as a man of remarkable scientific attainments. The history of the gradual evolution of his system of shop management, his successful efforts to systematize and conserve labor, and the experiments in evolving high speed steel, reads like a romance.[1]

The fundamental principles of Mr. Taylor's system are definite, and are set forth by him as follows:[2] —

[1] The writer attended Mr. Taylor's several lectures before students in the Graduate School of Business Administration, Harvard University. He has also seen the practical application of the new system in the plant of the Tabor Manufacturing Company of Philadelphia, where Mr. H. K. Hathaway, vice-president of the company, took considerable time and pains to explain it thoroughly. Scientific management has practically revolutionized the work of the establishment. Before its introduction there were more than 100 workmen at the machines and less than 6 men in the office; now there are 70 workmen in the shop and 30 men in the office and planning department and the output has been increased over 300%.

[2] From a paper read by Mr. Taylor before the American Society of Mechanical Engineers, June, 1903. Mr. Taylor is a former president of the society.

First. Each man in the establishment, high or low, should daily have a clearly defined task laid out before him. This task should not in the least degree be vague or indefinite, but should be circumscribed carefully and completely, and should not be easy to accomplish.

Second. Each man's task should call for a full day's work, and, at the same time, the workman should be given such conditions and such appliances as will enable him to accomplish his task with certainty.

Third. He should be sure of large pay when he accomplishes his task.

Fourth. When he fails he should be sure that sooner or later he will be the loser by it.

When an establishment has reached an advanced state of organization, in many cases a *fifth* element should be added, namely, the task should be made so difficult that it can only be accomplished by a first class man.

Under the first principle, the difference between the Taylor plan and ordinary practice lies in the very careful study (by experts with stop watches) of each element in each task, so that definite information is available as to how long it should take. In ordinary practice, the fixing of piece work rates is left to the judgment of the foreman or piece work specialist, and the rates are often changed. Under Mr. Taylor's plan rates are inflexible unless conditions change.

In the application of the second principle, Mr. Taylor goes much further than is customary in standardizing tools and machine accessories, and systematizing the storing and distributing of materials, sharpening of tools, and the like. Two unique features are the planning department and functional foremanship, the latter calling for a corps of specialists, each with a single function, instead of the military type of organization, under which the foreman is responsible for the work and discipline of all the men under him and all the machines which they use. The planning department is designed to take out of the hands of foreman and men all the planning of work and how it is to be done. The workman is merely to act upon written instructions. To make sure that the work is properly performed, the supervision formerly divided between the superintendent and foremen is assigned to a number of persons: (1) the gang boss, who has charge of the preparation of all work up to the time it is set in the machine; (2) the speed boss, who sees that proper cutting tools are provided and machines properly operated; (3) the inspector, who is responsible for the quality of the work; (4) the repair boss, who sees that the workmen keep their machines clean and properly oiled; (5) the route clerk, who lays out the exact route by which each piece of work must travel from machine to machine; (6) the instruction card man, who has charge of making up written instructions for each job; (7) the time and cost clerk, who prepares accurate cost data; and (8) the shop disciplinarian, who handles all matters of discipline and adjustment of disputes.

The foregoing briefly describes what is meant by scientific management in shops. As a system, its details have been well developed and it is in successful operation in a number of important manufacturing establishments. For branches of railroad work outside the shops, however, no definite plan has been worked out, nor have any experiments been made to determine whether the principles or details of shop scientific management are superior to the best practice of well-managed roads in activities outside of the shops.

Mr. Brandeis, in his brief in the rate controversy, is not so definite. He describes scientific management as involving a careful analysis of each unit, and a comparison of each of the smallest steps in the process with an ideal of perfect conditions. The system means, he says, that before anything is done, it must be determined what shall be done, how it shall be done, and what it shall cost. Planning in advance, he explains, is the essence of the new system. It affords a stimulus to workmen in the form of a higher rate for greater output. It shifts the burdens of management from employee to the management, where they belong. It demands universal preparedness, full and complete records, and the ascertainment and application of the best attainable methods, practices, tools, and machines; and it means further that all tools, machines, and appliances shall be properly standardized and in perfect condition.

This summation is admirable so far as it goes, but it is incomplete. The features which fail to get mention are very important and probably are those upon which Mr. Taylor would place strong emphasis. Nothing is said about the long time required for patient and careful study in the introduction of the Taylor system, nor its delicacy of adjustment, calling for thorough and painstaking effort. There is no reference to the difficulty of finding exceptionally skilled experts to specialize in the new field of transportation. The number of such experts is exceedingly small. These omissions in setting forth the scope and plan of scientific management are of serious consequence, since the public is only too ready to believe in new treatments, and as a result a swarm of unqualified or imperfectly qualified "physicians" is already appearing. The railroads are continually importuned to adopt schemes or devices which their originators believe will bring large returns, but which are obviously impractical or are likely to be vitiated in experience by some fatal defect. After many experiments of this kind, the railroads are naturally wary or skeptical. It is of the greatest importance, both for the railroads and the system of scientific management, that a clear distinction be made between the genuine thing and the poor copy. Amidst diversity and disagreement of doctors, railroad men, with large responsibilities, may well hesitate and insist upon proof before accepting the new doctrine.

To what sources may they turn for this proof? Unfortunately, a convincing demonstration, either affirmatively or negatively, is yet to be made in railroad operation. Only in textile mills, printing and binding concerns, and other manufacturing establishments is there ample proof that scientific management is both practicable and profitable, that it has increased output and at the same time decreased cost. The testimony before the Interstate Commerce Commission is replete with concrete illustrations of substantially increased net returns, notably in the cases of the Yale & Towne Company, The Link Belt Company, Tabor Manufacturing Company, Brighton Mills, and Plimpton Press.

The only instance of the application of something similar to the Taylor system in railroad operation is the experiment made on the Atchison, Topeka & Santa Fe Railway in 1904–07 by Mr. Harrington Emerson, president of the Emerson Company of New York, who are standard practice and efficiency engineers. Mr. Emerson is the author of the inspiring book, *Efficiency*, and an earnest advocate of advanced methods of securing efficiency. He has had a wide experience in installing his system in industrial establishments and has devoted much time to developing a plan particularly adapted to railroad shops. The results, as described in articles by the editor of the *Engineering Magazine* and by Mr. Emerson himself in several articles and lectures, indicate on their face that the workings of the new system were remarkably successful. In selected items of expense and unusual units of cost, large savings are shown. In one minor item, the maintenance of belts, astonishing results were achieved by more scientific treatment from workman to purchasing agent.

It will be remembered that Mr. Emerson was the authority for the statement that the railroads, by the adoption of scientific management, could save a million dollars a day. While it is not clear from his testimony before the commission, Mr. Emerson has stated elsewhere how he arrived at his estimate of a million a day.[1] He took the last statistical report of the Interstate Commerce Commission and applied to each grade or class of employee and cost of materials the percentage of efficiency obtaining in railroad operation at this time, according to his observation and judgment. Thus he ascertained what it would have cost to run all the railroads at 100% efficiency. He believes, for instance, that shops are but 60% efficient; section forces, less than 50%; stationmen, 60% to 80%. Applying the same process and reasoning to the cost of materials, he estimates, for example, that fuel consumption is but 50% efficient. It requires an average saving of approximately 23% in all items of expense to reach a million per day. If the saving applied only to the accounts specifically referred to, namely, section forces, shops, fuel, and freight sta-

[1] The writer had the pleasure of discussing this subject personally with Mr. Emerson.

tions, it would be necessary to reduce each of these by 50%. In either case, the operating ratio must be cut down from 66% to 51%. The result would be also that 310,000 workmen out of a total of 1,500,000 would be dispensed with.

Since this one example of efficiency methods is held up to the railroads for emulation, it is advisable to call attention to certain conditions, not emphasized in the descriptions of accomplishments; not with any thought of minimizing the good that was accomplished while Mr. Emerson was with the Santa Fe, but to explain why the results of the experiment are not convincing.

In the first place, the new system was introduced in the Santa Fe shops just after the collapse of a lengthy strike of machinists. Shop forces were demoralized and maintenance costs abnormally high, because of the inevitable employment of incompetent men to take the place of the strikers. A return to normal conditions, under any system, would have shown a marked improvement when results were compared with the former abnormal period.

In the second place, the introduction of high-speed steel for tools for cutting and drilling was coincident with the installation of Mr. Emerson's system, although not one of its distinct or unique features. High-speed steel was in general use before that time in other railroad shops; in fact, railroads were among the first extensive users of Mr. Taylor's invention. It is certain that the Santa Fe would have adopted the new tool steel, as other roads had already done, even had Mr. Emerson's system not been adopted. Mr. Taylor's new steel revolutionized the art of cutting metals and very much reduced shop costs. A large part of the Santa Fe saving, therefore, was due as much to high-speed steel as to the new system of management.

In the third place, Mr. Emerson's usual method of expressing the expense of locomotive maintenance is in cost per "road unit." This is an unusual and misleading average because it includes the weight of the locomotive as a factor and assumes that the repair cost varies directly with the weight. It assumes that an engine weighing one hundred tons will cost twice as much to repair as one weighing fifty tons. This assumption is not entirely incorrect; it is true that a heavy engine costs somewhat more to maintain than a light one. But the cost of repairs does not vary directly with weight. In this case, Mr. Emerson's unit gave a favorable showing to the new system, because of the purchase of a large number of new and heavy locomotives during the first two years under his régime. Naturally, the new engines did not call for the same measure of repair work as the older ones, which had kept up the cost in the previous period with which the comparison was made.

The unsatisfactory character of the ordinary accounting unit, "cost of repairs per locomotive mile," is recognized. Yet, with a knowledge of conditions, it is a better index than the Emerson unit, which assumes that cost varies directly with weight. The most reliable indication of cost of maintenance is afforded after all by the "per mile" and "per year" figures in the annual reports. In the figures tabulated below, comparison is made between the Santa Fe and the Union Pacific, running through similar territory to the north, and also the Southern Pacific, running through similar territory to the south. It will be noted that the Santa Fe costs have been steadily higher since 1903 than those of either of the Harriman lines. Taking the average of the seven-year period following the introduction of the new system on the Santa Fe (1904–10), its "per mile" costs are 20% higher than the Union Pacific and 14% higher than the Southern Pacific.

COST OF LOCOMOTIVE REPAIRS AND RENEWALS

Year	*per mile*			*per locomotive*		
	Santa Fe	Union Pacific	Southern Pacific	Santa Fe	Union Pacific	Southern Pacific
1903	9.97c.	10.39c.	8.62c.	$3,042	$3,590	$3,289
1904	13.42	11.23	10.33	3,772	3,565	3,588
1905	14.87	11.56	11.23	4,165	3,791	3,473
1906	11.08	8.61	11.26	3,101	3,068	3,531
1907	10.50	8.66	10.48	3,037	2,933	3,563
1908	13.74	10.70	10.79	3,714	3,108	3,234
1909	11.95	11.50	11.85	3,133	3,149	3,182
1910	12.87	11.72	11.63	3,832	3,656	3,551

In his testimony before the Interstate Commerce Commission Mr. Emerson referred to the time taken to give a locomotive shop repairs. By his system the time was reduced from sixty to thirty days. To the uninformed public this would seem a gratifying accomplishment. But even thirty days is too long. Many of the railroads do better. On the Chicago & North Western, for instance, the average is fifteen days. In this case again the improvement is relative only. The final results are no better than the average of other roads, nor as good as those of roads which are very well managed.

Since the Santa Fe experiment lacks convincing proof, the railroad manager must turn to the records of the manufacturing establishments where scientific management is known to be eminently successful. The impulse of the railroad man, as well as of the manufacturer, is to acknowledge the benefits of the system elsewhere, but to doubt that it can be successfully applied to the complex details and difficulties of his business with which the efficiency experts cannot be intimately acquainted. His first answer usually is, " This may work elsewhere, but not in my plant." But open-minded railroad men, while admitting that they may be giving a stereotyped objection, and that in the course of years some roads may find features of value in the system of management thus rudely brought to their attention, may nevertheless urge with good reason that especial difficulties stand in the way. The success of scientific management in commercial undertakings does not in itself prove that the new system would be equally effective in railroad work. The essential differences between railroads and manufacturing establishments must be borne in mind. These differences may be summarized under four headings: (1) area and extent of activity; (2) nature of product or output; (3) relations with the public and the government; (4) relations with labor unions.

(1) The differences in area and extent of activity are obvious: the manufacturing establishment with its concentrated forces and intensive activity; the railroad with its long lines of communication, scattered units of organization, and extensive range of action. Railroad forces, spread out thinly over the line,

necessarily work under scant supervision. Section forces, stationmen, signal and repair men, car inspectors and oilers, work-train and way-freight crews, and many other employees located in small groups at intervals of two or three miles, must be left largely to themselves, and their work checked chiefly by inspection. It is obviously impracticable to afford the constant supervision which is such a vital part of the new system. In a manufacturing plant thousands of men may work in one group of buildings, subject to the supervision not only of gang bosses and foremen, but also of all officers and owners of the establishment. In contrast, compare the one item of section forces. Gangs of six to ten men are scattered over every section of three to ten miles, the average being one man per track mile. This attenuated line of two or three thousand laborers on a double-track road, say, from Boston to Chicago, a distance of more than a thousand miles, could be concentrated on one acre in a textile mill.

(2) With respect to the nature of product or output, there are also distinct differences between an industrial establishment (such as the Tabor Manufacturing Company), with a uniform output, and a railroad repair shop, where there is little uniformity in the work. The cost of the work in a railroad shop is a small part of total operating expenses.[1] Shop and repair work is incidental to the main function of producing transportation. The value or efficiency of railroad shop work depends upon how well it assists in the safe and expeditious movement of passengers and freight. It cannot be systematized to the same degree as in manufacturing shops, where the character of the work varies but slightly. Oftentimes, too, it is much more important that railroad repair work be done quickly than at the lowest possible cost. This feature applies particularly to repairs made at the engine houses and outlying car inspection points.

In railroad shops which carry on the manufacture (as well as the repair) of locomotives and cars, it would be practicable to adopt a large part of Mr. Taylor's system. But such shops are relatively few in number. The great majority of the railroads

[1] The cost of maintaining locomotives and cars averages about 18% of operating expenses.

find it cheaper to purchase their rolling stock, because the best use of the railroad shops and the mechanical department organization is to maintain, not to manufacture. It has been found that they cannot compete on even terms with an industrial concern which specializes in manufacture.

(3) Quite apparent, also, are the dissimilarities between railroads and private concerns in their relations to the public and governmental regulating bodies. A railroad is a public service corporation. The public rightfully demands that adequacy of service shall outrank the payment of dividends. A manufacturing establishment exists solely for profits. If it ceases to be profitable, it may close its doors or change the nature of its business. The operation of an unprofitable road must continue. It has two functions, public service and profit making; it may not neglect service to favor profits. Necessarily, therefore, methods are employed in the interest of public service even though they involve economic loss, and would not be resorted to if railroads were operated as private industries.

For example, paralleling lines, trolley competition, or other changed conditions may make certain divisions, branches, or trains unprofitable; yet satisfactory service must be continued, with little thought of returns. The losses from such divisions, branches, or trains are perforce absorbed in the earnings of the trains which are better patronized. Again, the demand for prompt and regular movement of freight often results in cars being moved with a light load. If they were held for a full load, the regularity of the service would suffer. As a result only one-third of the capacity of freight cars is utilized.[1] In other ways economies in railroad operation could be brought about at the expense of the service; but these are desired neither by the railroads nor the shippers.

The effect of governmental regulation is much more apparent in railroad operation than in private industries, and, while both proper and desirable, it adds to the cost of operation. Mr. Howard Elliott, president of the Northern Pacific Railway,

[1] The average capacity of freight cars in the United States is 35 tons. The average ton miles per loaded car mile is 19.3.

recently[1] stated that the cost to the railroads of the United States for board and commission control amounts to $85 per mile of road per annum, an aggregate of $20,000,000. This regulation affects nearly every detail of operation. Though justified by public policy, and apparently necessary to keep all the railroads up to a standard which the well managed might adopt without governmental requirement, it has an important bearing on any comparison which may be made between railroads and manufacturing establishments not so circumscribed.

For the safety of trains, again, every precaution must be taken to avoid accident. Methods which might reduce costs but which would also add to the element of risk are necessarily barred. For that reason certain classes of work are performed under day rates rather than by piece work. It is more important to have the task well done than to make a slight saving in cost. One accident as the result of such apparent economy would offset the savings of a long time.

(4) Perhaps the greatest barrier to the introduction of any system designed to accomplish savings which will diminish the number of employees is the labor organization. Practically every branch of the railroad service is strongly organized and militant. The manufacturer has his labor problem also; but he can close down his plant or lock out his men if he sees fit. With railroads, resistance to demands considered by them as unreasonable must not be allowed unduly to affect service. Trains must be kept moving at any cost, and if men cannot be had to take the place of striking employees, or if, before a strike is declared, it is plain that resistance is useless,[2] the company must make the best terms it can, and maintain peace.

Any system or contrivance which has for its object the creation of competition among workmen, or which will cause them to exert themselves, is repugnant in principle to labor leaders. Its direct result, as they see it, is to "speed up," and to lessen the

[1] Address before the Minnesota Federation of Commercial Clubs, January 26, 1911.

[2] This was the situation a year ago on the Baltimore & Ohio, Lackawanna, and New York Central roads.

number of workmen. Their attitude is indicated by the strong opposition of the Brotherhood of Locomotive Engineers to the introduction of the Mallet compound locomotive. This type of machine is capable of handling very much heavier trains, but calls for no more effort and very little additional skill on the part of the engineman. The organization held out strongly for double pay, on the theory that the Mallet engine does twice the work of an ordinary engine and, if ordinary engines were used instead, double the number of enginemen would be necessary. The issue came near precipitating a strike on all the western lines last fall, but was finally settled by mediation under the Erdman Act, the enginemen receiving a bonus of $1 per day over the highest existing rate, instead of double pay as demanded. This settlement, however, will hardly be permanent. Opposition will probably continue and the question will undoubtedly cause friction in future negotiations between the railroads and their enginemen.

Of similar significance are the organized efforts of conductors and trainmen to prohibit double-heading. By this is meant the practice of running two engines on a freight train so as to increase its length. The resulting decrease in the number of trains and the consequent smaller number of train crews are opposed by the men.

The year 1910 saw the successful culmination of an ambitious plan to " standardize " the wages of conductors, trainmen, and yardmen in the eastern states, that is, to set a uniform rate per day, per hour, or per mile for each class of service, regardless of local conditions.[1] The road with the highest wage scale (the Baltimore & Ohio) was selected as the battle ground, and the entire forces of the train-service brotherhoods focussed upon it in a demand for new and unreasonably high rates. To prevent a strike, the railroad invoked the aid of the Board of Mediation (under the Erdman Act), and the award, while not granting the rates demanded, carried with it substantial increases over rates already considerably higher than those of other roads in the East

[1] See a paper by the present writer on " Standardizing the Wages of Railroad Trainmen," *Quarterly Journal of Economics*, November, 1910.

with distinctly different operating characteristics. The new basis was then in turn forced upon practically every road in eastern territory. The increases in New England averaged between 20% and 30% and in some cases exceeded 50%. At the same time long-standing differentials between different grades of employees were seriously disturbed. Throughout, the new wage basis and working rules (prescribed partly by governmental mediation) are far from scientific or equitable.

At this writing (April, 1911) the boiler makers of the New York Central lines have been on strike for ten weeks because of the introduction of piece work rates at Collinwood, Ohio, on the Lake Shore Railway. Undoubtedly, former abuses of the piece work basis have much to do with the determined opposition to its introduction in this case. Yet the same opposition would probably have occurred if it had been the Emerson bonus plan used on the Santa Fe. In fact, the head of the strongest organization in railroad service is reported as having said that the bonus system and his organization could not exist together on any railroad.[1]

These difficulties, serious as they are, may be met by experts. But the railroad man sees no definite plan for the application of the new "principles"; and he has a fondness for the concrete. After studying scientific management as applied to shops he realizes that when similar efforts are made to extend it to the whole line of railroad operation, long and expert study will be needed, and new and unsuspected modifications of the system must be made to meet the exacting conditions of railroading.

The technical record of railroads in the United States is creditable. They have had to meet exceptional difficulties. In their effort to keep pace with the commercial development of the country, a policy of expediency has in many cases justified standards of construction, maintenance, and operation which would have been considered faulty in an older country, like England, whose railroads came after, not before, her industrial growth and dense population. But in the past two or three decades many deficiencies have been corrected and the work of eliminating other imperfections is progressing.

[1] Warren S. Stone before the National Civic Federation, January 12, 1911.

In the interest of a clearer understanding of the situation by the public, it would have been worth while for the railroads to offer more of constructive evidence to show that although scientific management, as a system, has not been adopted by them, yet the principles of sound business management have free play in a large number of shops and other railroad operating activities. So far from being ignorant as to costs, many roads have statistical departments which compile and disseminate information upon every detail of operation, so that each unit of efficiency may be compared with other units, or with the same unit of another division, another railroad, or another period. Instead of being out of date in shop equipment, or behind the time in shop practice, they are, on the average, in advance of manufacturing establishments. They might have shown further that railroads, while far from perfect, are constantly improving in efficiency; that railroad officers, both of the so-called " practical " school and those who are graduates of colleges and technical schools, are earnest in their effort and have ample incentive to operate economically. Railroads believe in and practise the free and frequent exchange of ideas by associations and clubs which include every branch of the service. In fact, they are unique in having so few secrets concerning operating methods, and in their willingness to tell of, hear about, and profit by their mutual experiences.

As an illustration of the work of one association, witness the monthly reports of the Car Efficiency Committee of the American Railway Association. The statistical exhibit, showing every detail of operation and revenue connected with freight movement on every railroad in the country, is a convincing example of the scientific thoroughness with which such information is compiled and distributed for mutual benefit. Every department has its association doing similarly scientific work. As other instances, take the Railway Engineering Association and its careful studies and experiments in perfecting rail design and cross-tie preservation; the Master Car Builders' Association and its exhaustive tests of air-brake apparatus; the Master Mechanics' Association and its painstaking efforts to evolve a perfect super-heater and mechanical stoker; and the Railway Signal Association and its thoroughgoing work of standardizing the art of signaling.

There may be ground for the impression that railroads are in a class by themselves in an attitude of self-sufficiency, that is, a belief that they can learn little from the experience or ideas of those outside the railroad circle. Yet that this is not altogether true, and that the railroads not only welcome but seek assistance from outside experts, is shown by the establishment of the Bureau of Explosives. This bureau was organized under the auspices of the American Railway Association about five years ago by Colonel Dunn of the ordnance department of the United States army, working closely in conjunction with the late Dr. Dudley (then chief chemist of the Pennsylvania Railroad) and a committee of other railroad officers from different sections of the country. The American Railway Association realized that they did not have a man within their ranks with the same wide knowledge of the characteristics of explosives and the best manner of handling them, and were glad to secure Colonel Dunn's valuable services. He has accomplished much in organizing a system and formulating rules of inspection which have reduced to a very large extent the accidents formerly frequent in the transportation of this dangerous class of freight.

In the committee work of the Railway Engineering Association, Master Car Builders, Master Mechanics, Signal Engineers, and other railroad technical associations, the coöperation and active assistance of outside experts is sought. There are eleven university professors on the various committees of the Railway Engineering Association. In the active work of the railroad mechanical associations there are as many more, notably Dean Goss of the University of Illinois, Professor Hibbard of the University of Missouri, and Professor Benjamin of Purdue University.

The railroad man, knowing how keen is the anxiety of his profession for improvement and vigilance, has been and is proud of the achievements of American railroads. He believes that railroad efficiency is higher than the average in manufacturing establishments, and can hold its own with any line of enterprise in the United States. He thinks, too, that in the recent rate hearings the railroads should have been measured not with the exceptional industrial establishment, but with the average. He recognizes, none better than he, the existing deficiencies in railroad management; but that they are greater or more flagrant than those in other large undertakings he will not admit. The extended area of railroad activity and the problem of adequate supervision make it difficult to secure high efficiency and use of materials. The tendency of labor union policy is increasingly to trammel the manager. He is also hampered by the difficulty of securing competent men in supervisory positions. Expert knowledge is not required to point out losses and inefficiencies. They are apparent. But criticism should be accompanied by practical remedial suggestions.

The history of American railways shows that their progress has been steady and substantial. A comparison of any two periods ten years apart will reveal impressive increases in efficiency. The net train load, for example, has increased nearly fifty per cent in the last ten years. Such advances in nearly every case have been the result of development and improvement of existing methods and facilities. The new and improved have been the adaptation of the old. And judging by this steady improvement in the past, it may be expected to continue in the future.

The solution of the problem of how to effect further economies and yet maintain good service seems to lie in a more rigid application of the railroad's own kind of scientific management and a continuation and enlargement of the best practices of the best railroads, so that the operating results of the least economical may approach those whose efficiency is marked, and these in turn set new and higher standards. A new system is not needed so much as a more determined, and a more general application of the sound and business-like methods which have already been found effective in railroad work.

After all, there is little essential difference between the aims and accomplishments of scientific management as advocated by the new experts and scientific management as practised by the exceptionally well-managed railroads. As a system, it means a careful study and analysis of each element of operation, and the application of the methods best adapted to bring about the best results under the given conditions. Many railroads are doing this successfully; others are doing it in part. In the nature of things, however, their efforts have been directed more to the "high spots" or to those features of operation which are most in need of correction or which promise the largest or quickest returns. Scientific management, as a system, takes a broader view and requires that the same careful study and treatment be given to every detail of operation as is given, say, to the subject of train loading. Obviously, there is a point where this would be unprofitable, — where the cost of the system would exceed the saving.

The real difference, then, between the efficiency experts and the railroads in their conception of scientific management is not in kind but in degree. To find a common ground means mutual concessions. On the part of the efficiency expert it will require less stress upon "system," "principles," "dependent sequences" it will require more knowledge of the practical problems of railroads, more respect for what the railroads have accomplished, and less exaggeration and generalization concerning waste and possible savings. On the part of the railroad a more receptive attitude is needed for suggestions from the outside and a recognition of the fact that, notwithstanding commendable progress in operating economies, much yet remains to be accomplished.

Among the important features of Mr. Taylor's system of shop management, the principle of time study might well become a part of the practice of any railroad shop with a piece work basis. The piece work schedules of today are generally an evolution from "cut and try" methods. Their defects are recognized. Mr. Taylor's second principle, of standardized conditions, is equally important, and many railroad shops come reasonably close to standard practice.

But apart from shop operation, other and greater avenues of economy are being earnestly studied. The delays and red-tape obstructive to local initiative,[1] will yield to some plan of decentralizing authority, such as is now being tried on the Harriman lines. There are undoubted economies in further standardizing of equipment and materials, as well as in improved methods of storing and distributing supplies. There is promise of economy in the experiments now being made by the American Railway Association in clearing-house accounting for joint use of cars. A substantial saving in fuel may be made by a more general adoption of the methods of the roads having the best fuel records. And throughout the service there is crying need for more and better supervision.

Better supervision calls for better men, and to that end the educational activities of the railroads should have wider scope and more effective organization.[2] A system of management is not needed so much as managers. The system is not as important as the man. A good system will not altogether save a poor manager, nor will an imperfect system altogether hold back one who is ambitious and able. Mr. Taylor himself recognizes this in his statement, " the first object of any good system must be that of developing first class men." [3]

Except in the important particulars of time study and functional foremanship, the system advocated by the experts and the

[1] Mentioned by W. M. Acworth, the English economist, as a defect in American railroad organization. In the same statement, made on the eve of his departure February 1st last, he expressed surprise that the newspapers should give so much space to criticism of railroad efficiency. In his opinion American railroads are the most efficient in the world. He believes that the skeletons in the railroad cupboards have all been buried and that now the roads " would do well to open their cupboards and let the public see how sweet and clean they are."

[2] J. Shirley Eaton, in *Education for Efficiency in Railroad Service* (1909), says: " In the course of railroad development, there was a first era, which was the era of railroad building. Any railroad was better than a wagon road. There was next an era of coördination of the railroad service and finance to the commercial and financial conditions as a whole with which the railroads were called upon to deal. This was the time of the traffic organization and railroad consolidation. Next came the era of internal adjustment on the physical and mechanical side — perfection of machinery, cutting down grades, strengthening bridges, increasing the train unit. And now has come the sociological adjustment. The human part of the machine is quite as vital as the steel and wooden part in producing efficiency, and so in increasing the income."

[3] *American Magazine*, March, 1911, p. 570.

system practised by the railroads are not very far apart. Both have for their object that which is desired by the railroads and the public, — ability to give good, safe, and economical service. And if achieved either by an improvement of present methods, or by an adaptation of the new system, private management of railways will have strengthened its claim to continuance.

THE APPLICATION OF SCIENTIFIC MANAGEMENT TO A RAILWAY SHOP

By H. F. STIMPSON

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The object of any legitimate organized enterprise is to serve beneficially the entire community. A railway company is an instance of such an effort. In order that the effort may be successful the efforts of all its constituent parts, of which the shop is but one, must be intelligently coördinated and directed toward the common end. This is scientific management. To this end it is necessary:

(*a*) To determine the present and estimate the future opportunities for service.

(*b*) To determine the material, equipment, energy and administrative methods which are necessary for the performance of the service.

(*c*) To procure the requisite capital.

(*d*) To make proper records of the ensuing operations and transactions.

The immediate duty of that part of the railway organization which operates its shops is to fabricate or keep in repair that portion of the equipment by which the service to the community is directly rendered. The shop organization is, therefore, neither a beginning nor an ending; it is but a portion of one of the principal intermediaries — the operating department. The volume of the shop operations is dependent on the volume of the business developed by the traffic department, and is largely affected by the efficiency with which the train crews, etc., handle the equipment with which they are entrusted. The resources at the command of the shop organization are derived from the financial department and are also largely affected by the efficiency with which the operating equipment is handled.

The shop organization, therefore, is not and cannot be considered as a separate entity. This must be taken into account in considering any question of shop management. In any line of reasoning we must have a starting point. The position which the community, through its Interstate Commerce Commission, has recently assumed regarding an increase of rates, goes to show that the present, or lower, instead of the higher rates must be taken as being such a point. While the charge against new construction is a charge against capital account, the interest on this as well as the cost of repairs on both transportation and shop equipment becomes an overhead charge on the direct cost of transportation. If then the rates are fixed, it is desirable that both the amount and cost of all shop operations be reduced to the lowest possible terms in order to reduce the overhead charge on the direct cost of transportation.

Any waste here or in any other contingent operations will either increase the cost or decrease the quantity or quality of the service rendered to the community, of which each of the workers is a part, whereas the attainment of a high state of efficiency should result in a decrease in cost or an increase of the quantity or quality of the service, thus benefiting the community. The interests of the community as a whole, of the stockholders as such, and of the workers as such are, therefore, identical. If the operation of the railway results in over or under protection to any of these interests, it will be because either the industrial or commercial management has been inadequate. If the industrial management has failed, the actual cost of production will be found to have been unduly increased. If the commercial management has failed, the profits will be found to have been improperly divided between worker, stockholder and community.

Because the shop organization is, as has been said, neither a beginning nor an ending, but simply a part of an intermediary, it is as unwise to attempt the immediate and exclusive application of the principles of scientific management to such organization as it would be to develop one leg of a horse. We must consider both the things which precede and the things which follow its operations. For instance; I was told, with much pride, by a shop manager of the number of locomotives which came out of his shop each month. This was not of much importance. The important thing was the time which each locomotive had been withdrawn from service. I was perfectly convinced from what I saw, being accustomed to observe such things and to draw correct deductions therefrom, that, if a chart had been made showing the chronological durations and relations of the actual operations performed, it would have been found that not only were there large wastes of time in the performance of the individual operations, but between them. Not the least evidence of this condition was the difficulty the executives had in comprehending the possibility of such a thing. They were not interested in searching for a remedy for a disease which they did not believe existed. Here we have a diminution of earning power co-existent with the increased cost of repairs, both of which add to the overhead charge, thus burning the candle at both ends.

To arrive at correct conclusions, we must first have complete and accurate statements as to what should have and could have taken place (standards), as well as of what has taken place (records). Liberal expenditures of both time and money are necessary in order to obtain these, but these expenditures are insignificant when compared with the savings which should result from their use.

Taking the maintenance side of the question, the first step should be to separate the process of deterioration of the direct operating equipment into the preventable and the unpreventable factors; second, to determine the actual and necessary rate of each; third, the causes of each; fourth, the remedies for each so far as possible. We have now determined the necessary gross rate and volume of repair work which should come into the shop. From an analysis of this we can determine the unit operations together with the material, equipment and energy and administrative methods which are necessary for their performance. Scientific management, so far as the shop is concerned, is the process of properly supplying these essentials and of directing their use.

The first essential is material. Certain material is fairly standard as to quality and the rate of consumption. Other material is more irregular in both respects. In either case, as the result of the above analysis, the exact date of delivery to the shop can be and should be fixed both specifically and in detail by a person who is in a position to grasp the entire chain of operations in which the one involving the use of any bit of material is but a link. While this work is often delegated to or attempted by a foreman or other person immediately engaged in the performance of manual operations, it is evident that such a course is illogical. Not only is the foreman unable to grasp correctly the entire situation, but the ill effects of any erroneous sequence which he establishes will be felt throughout the entire organization.

Having been given the desired date of delivery to the shop, the storekeeper should set a date for delivery to himself which is sufficiently in advance to admit of the necessary examination, checking up and redelivery. The order should then go to the purchasing agent. Having been instructed as to the quality of the commodities and the date at which they must be delivered to the storekeeper, the only variables in the operations of the purchasing agent are price and time. It should be possible to establish his efficiency upon the basis of a compound unit composed of dollars and days. Thus a high price would be compensated for by the saving in the productive time of the operating unit, which could be effected by a quick repair resulting from a quick delivery.

The next essential is the equipment by which the material is fashioned, or the work performed. Equipment represents a capital investment upon which interest and depreciation must be earned. It is therefore desirable to use the smallest possible quantity by which, when operated to its fullest legitimate capacity, the desired amount of work can be produced. This condition is not often as closely approached as should be the case. Here again we must use compound units to measure results. The cost of interest and depreciation on the machine, the time of operation and the cost of power must all be taken into account.

It is conceivable that a quick acting machine might be so costly to maintain and to drive as to be far excelled by a slower machine which besides being far cheaper took less power to drive. Details of past accomplishments and the opinions of men and foremen in such matters are extremely unsafe and unsatisfactory as guides when contrasted with the cool scientific analysis of the efficiency engineer of the results which it is mechanically possible to achieve. There is, furthermore, a curious tendency to do things by halves, to utilize highly developed mechanical energy and appliances for a part of an operation and the crudest kind of methods for the rest. I have seen, in a railway shop, a highly developed press for forming boiler heads, operated by hydraulic pressure. The controlling valves, instead of being operated by mechanical energy through a secondary system of cylinders and pistons, were operated by human physical energy, applied slowly and painfully through levers. The same thing was true of the work of prying the heads from the dies where they often stuck. Boiler sheets were lifted and lowered over the jaw of a riveter by an expensive crane which was needlessly tied up on the job. The crane should have transferred its burden to a stationary hoist. Man, at a slow rate of speed, rotated the shell when rivetting the transverse seams. A vertical, power driven drum, cable-connected to the shell, should have done the trick more cheaply and quickly. These wastes clearly demonstrate the fallacy of depending on men immediately engaged in the direction of manual or mechanical operations for the evolution of operative methods.

The third essential is energy, of which there are two types — physical, which may be either of mechanical, animal or human origin; and mental, which is of both superhuman and human origin, the latter variety alone being under consideration at present. Human physical energy is essential to the control of either mechanical or animal energy. Human mental energy is essential to the direction of all types of physical energy.

Working back from the equipment, on one side we find in series, the tool, the generator, the engine, the boiler and the coal, which is one of the chief sources, terrestrially speaking, of mechanical energy. The boiler, engine, generator and motor are only the means whereby the latent energy in the coal is transformed, transmitted and applied to the tool. Controlling the tool we find the body of the man actuated by his mind which is his motor. Working back from the mind of the man, we find that it is at the end of a series composed of the minds of the foremen, superintendents, general manager, president, executive committee, board of directors and stockholders. The wish in the minds of the stockholders that a railway shall be operated for the purpose of making money is the real latent energy which, transformed and transmitted through the whole human organization finally reaches and is applied to the mind of the worker and causes him, by means of his physical energy, to put the mechanical energy into operation. If the various appliances by which the energy in the coal is transmitted to the tool are not suited to the end in view or are not properly connected, the result will be disappointing. It is even more true in the human machine or organization that there must be a sufficiency of adequate mind units, properly connected, to insure satisfactory results. A motor cannot be energized through a lightning rod by occasional flashes of lightning. It must receive a continuous supply through proper connections from an adequate generator backed by coal of high thermal qualities. Similarly a man must receive a continuous supply of mental energy through a proper organization from a competent executive backed by energetic stockholders.

As we have seen, the railway shop is but a part of one of the principal divisions of a railway organization. In a well-designed power plant there must be a principal steam drum main into which all the boilers discharge and from which all engines draw the necessary steam. This steam drum may be compared to the chief executive officer. The title of president, usually employed, is incorrect, being purely parliamentary and not executive in its nature. A better term would be general manager, as expressing universal control of the operating organization. The departmental managers, which are the heads of the principal divisions, may be compared to the generating sets by which the energy, focused in the general manager, is applied to the various phases of the business.

In a power plant, however, but little in the nature of a refining operation, except a certain amount of drying, is applied to the steam in the drum. In the case of the human steam it is different. The increase in the volume of ascertained fact, in recent years especially, has been so rapid that it is physically and mentally impossible for the general manager of a great railway or other industrial enterprise to acquire a complete acquaintance with that which pertains to his line of work. To overcome this difficulty, two general methods have been pursued, sometimes separately and sometimes in combination. The first method is to require each member of the organization to absorb such new information as pertains to his particular work. This is not advisable because it requires a man to carry on, simultaneously, two radically different lines of thought which require different conditions and equipment for their operation. Productive and investigative operations cannot be conducted at one and the same time with mutual advantage. The second method is to attach certain specialists, or energizers, to various parts of the organization to perform the investigative portion of the work. This is an improvement, but it fails of entire success because the effect of this disjointed advice on the other divisions of the organization has not and cannot be properly digested in advance of its application. It is only when these specialists are entirely withdrawn from the operating organization and separated into sections corresponding to the divisions above alluded to, and put directly under the control of the general manager that success will attend their efforts.

When, therefore, mental energy in the form of a direction or standard practice instruction is to be applied, it will have been considered from every possible standpoint; it will have received the final consideration of the chief executive, as to generalities, and may be fairly depended upon to produce the desired results.

In applying this theory the result would be the gradual withdrawal of the more able men from the directly operative work to the advisory work, their abilities being replaced by carefully prepared instructions. This would open up a line of promotion to the operating men which does not now exist. The result would be a development of workers, first into the administrative positions under carefully formulated instructions, and finally into positions on the staff which formulates these instructions. The expense of maintaining this staff would not be by any means an entire addition to the present operating cost, for most of the men are, at present, doing such work, but in the wrong place and under the wrong directions. Any additional cost which ought to eventuate would be many times regained from the increased efficiency of the great army of workers.

The fourth essential is the administrative methods by which proper directions for the utilization of material, equipment and energy are transmitted to the various units of which the organization is composed, and proper records are secured as to the results obtained. Both of these things are equally necessary for the comparisons which are essential to the successful control of any business.

The line of the outward flow of the directions must be carefully determined, in great detail, so that all units will receive their proper share of the directions in the proper sequence. The experience necessary to lay down these lines is, contrary to the common belief, quite distinct from that necessary to pass upon the subject matter of the directions. The phases of all such directions are much alike, as are the principal phases of all organizations. This is almost incomprehensible to those whose chief study has been that of the subject matter, but it is nevertheless true. The specialist in this work, therefore, finds much less difficulty in devising a proper routine for almost any business than the specialist in any one line would find in devising a routine for the business with which he is most familiar. The two lines of work are separate. The machinist can make a better typewriting machine than can the stenographer; though, being unable to compose the letters which are to be written upon it, he is unable to operate the machine to advantage after its completion. This the stenographer can do even though he is unable to construct the machine itself.

The line of inward flow of the records must carefully parallel that of the outward flow of the standards. The maxim should be a standard for and a record of every operation. Because frantic attempts have been made to deduce information from records alone, which it is impossible to get except from a comparison of records with standards, most concerns are loaded up with a vast amount of unproductive bookkeeping. It is quite possible to gather, at a large expense, masses of figures which never become of the slightest use, and to leave ungathered much data which is of extreme value. Hence the correct correlation of standards and records is of the highest importance.

Both standards and records, however, fail to be of use unless diligently studied by the various members of the organization, especially the chief executives. Of what use would be the most careful observations and plotting by the navigators of a ship if the captain did not digest the information and act accordingly? When the information has been put into proper form, the work of using it has not been even begun. For this reason the data should reach each administrator in such shape that only the problems suited to his rank will be presented to him for his solution, thus economizing his energy.

In closing this very brief discussion of the principles which should guide the application of scientific management to the railway shop and also, as is absolutely essential, to the entire organization, a word may be in order as to the characteristics of the efficiency engineer and the part which he should play. Such an engineer should be a corporation, or other aggregation of individuals, coördinated under a competent head and having among its members individuals able to advise in every form of administrative detail, both commercial, disciplinary and technical. No single individual can possibly have acquired the necessary breadth of experience which is necessary in order to properly handle directly all the detail of this work. Such an engineer should not under any consideration, attempt to do constructive work with his own men. He may and should employ such men for his investigations, which should be impartial and unprejudiced. He should lay down the entire form of the organization by offices, leaving the railway officials to fill them. He should revise the present routine and the forms which insure its operation, and make such specific recommendations as are necessary to bring about the desired condition. He should suggest the order of changes and promotions, but not pass upon the ability of the individuals to be affected by them. He should, directly or through trusted subordinates, give such explanations of new methods as are necessary for the proper understanding thereof, to any individual needing them. He should conduct such a process of friendly inspection, from the president down, as will determine, until the natural checks get into full operation, that the administrative operations are being properly performed.

This work will take several years in any railway for its accomplishment. Large results will not be seen immediately. Only patient and persistent effort and honest coöperation from all concerned will eventually produce them. Given these things, the results are sure to follow.

THE RAILWAYS AND SCIENTIFIC MANAGEMENT

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ENGINEERS and the public in general have become reasonably familiar through the daily papers with the novel line of reasoning offered by Mr. Louis D. Brandeis against the proposed increase in railway freight rates, permission for which was recently refused by the Interstate Commerce Commission. Mr. Brandeis contended that by applying the principle of scientific management it would be possible for American railways to save a million dollars a day in operating expense, and he produced expert witnesses to show the possibility of such a saving. While the Interstate Commerce Commission has decided adversely to the railways, the commission was not influenced by the testimony and arguments offered by Mr. Brandeis, nor is this to be wondered at. We quote from the text of the commission's ruling:

It was, however, earnestly insisted by the shippers that the railroad might and should find other kinds of economies with which to make good this increase in wages. Several prominent manufacturers testified that in their business in recent years wages had been advanced, but they had not been able to make corresponding advances in the price of their product, and were therefore forced to look about for other ways in which to take up the increase in the cost of production.

It was claimed that by the introduction of what was termed "scientific management," the purpose of which was in various ways to make labor more efficient, at the same time increasing the wage paid the laborer himself, much more than the amount of these advances could be saved.

One gentleman who described these methods testified that they had been introduced to some extent into the operations of railways with remarkable results, and that from a careful analysis and computation he was satisfied that not less than $300,000,000 annually could be saved by the proper application of these methods to the business of railroading in the United States.

It is difficult to see exactly what application the commission can make in this case of this testimony. The witness who apparently had most to do with the originating and applying of these methods testified that they were in actual operation in not over one-tenth of 1 per cent of all the manufacturing establishments of this country. The system is everywhere in an experimental stage. To some extent it has been tried, and is now being tried by our railways. The representative of railway labor who appeared before us stated that these methods could not and should not be introduced into railway work.

Upon this record we can hardly find that these methods could be introduced into railroad operations to any considerable extent, much less can we determine the definite amount of saving which could be made. We cannot, therefore, find that these defendants could make good any part of these actual advances in wages by the introduction of scientific management.

The weakness of the testimony given by the experts whom Mr. Brandeis had summoned is found mainly in the fact that few of them had ever done any railway work at all, and the one or two who had been engaged on efficiency engineering by railways seemed to be unable to cite many "repeat orders." But our readers should not let this fact influence their judgment, although it necessarily had weight with the commission. There are engineers known to the editors of this journal, and among them are editors of this journal, who, for years past and right now, are applying the principles of modern scientific management to railway operation with success. Obviously certain of these engineers would not appear as witnesses against the railways in a rate case if they could, and some of them couldn't if they would. The latter would lose their positions if they did. The former feel that, while it is a fact that railway operating costs can be greatly reduced by scientific management, it is not logical nor fair to offer that as an argument against the advance of railway rates now. It would be equally reasonable to demand a lowering of the price of every manufactured product in the world on the ground that it is possible to reduce the unit cost of every product.

We who have knowledge of the great, and often astounding, economies that have been effected by scientific management also have knowledge of the extreme slowness with which it can be introduced. Even on a small railway it is a matter of years to effect changes in methods, so firmly fixed are the prejudices in favor of "the good old way." It may almost be said to be a law of human nature that it takes twentyyears to introduce and popularize an entirely novel machine or method for economizing labor.

First, there is the resistence of owners and managers to be overcome. They are quite certain that they cannot be taught more economic ways of production. Second, there is the resistance of foremen. They are absolutely certain that the innovation will be fruitless. Finally there is the rock-founded resistance of the workmen to any device or method that seems likely to effect a saving of labor. We have seen all three of these elements at work in this particular case before the Interstate Commerce Commission. From railway presidents down the line to superintendents have issued derisive statements as to the possibility of any radical reduction in operating costs by application of scientific management. And even the labor unions sent their representatives to testify that " these methods could not and should not be introduced into railway work."

As to the latter, we may reply that " these methods " have been and should be introduced into railway work. Moreover, the workmen have been the greatest gainers where " these methods " have been introduced.

While we do not believe that the railways should be denied increased rates because of economies in operation that may be effected in the future, we do contend that it is a false position for railway managers to take when they scout the possibility of greatly reducing operating costs. Most of them know that decided reductions in cost are not only possible but are actually being affected. If they will study the laws of scientific management, they will find that the principles they have been deriding are the very ones they have been applying, at least in part. They will see that true scientific management is not a few special methods of timing and scheduling work, but that it embraces a system of laws that are founded on experience, and many of which are as old as industrialism itself. They will also learn that there is fundamental difference between following a law unconsciously, by intuition, and following consciously; for in the latter case management becomes truly scientific, while in the former case it is merely an art. Science can be taught. Art is mainly acquired by practice, and then only by those naturally gifted.

One of our engineering contemporaries, *Engineering News*, has also upheld the contention that Mr. Brandeis is ludicrously wrong in asserting that scientific management can be applied in railroading. The *News* holds that the management of a railway is quite unlike the management of a factory, and resembles closely the management of a household. It asks the exponents of scientific management to apply their theories to their own house servants, and then report results. It avers that the number of railway station agents and the like is fixed by conditions, and cannot be reduced, and that the same holds true of trainmen and most other employees.

Our contemporary may be interested in knowing that the writer is now writing in a hotel that has reduced its expenses and increased its net income remarkably within a year by applying the principles of scientific management. In fact the hotel under its previous management had gone into the hands of a receiver. Whereas now it is highly profitable. So even a large household such as a hotel is can be reorganized and made profitable by scientific management.

With regard to railways, however, there is vastly more of the factory than there is of the household; and this is best seen by studying the percentages of the different operating cost items. Wellington has well said that a railway is a factory for manufacturing transportation. The maintenance items alone total more than 40 per cent of all the operating expense; and maintenance is nearly all analogous to factory production in so far as the principles of scientific management are concerned.

Fuel for locomotives is another big expense that may be called a factory item. So, too, are train crew expenses. While the number of men on each train may not be decreased by scientific management, the number of daily train miles per crew can certainly be increased by improved management.

Train loads have been increased remarkably by reducing grades. Yet the man who is father of the principles that engineers apply in determining the justifiable expenditures for grade reduction, the late A. M. Wellington, may well be called an exponent of scientific management in certain phases of its application. Let it not be supposed that scientific management is a thing entirely new, or that it relates wholly to factory work, or that it involves nothing but handling men, or that any single engineer originated all its principles. As we conceive it, scientific management consists in the conscious application of the laws inherent in the practice of successful managers and the laws of science in general. It has been called management engineering, which seems more fully to cover its general scope of the science.

It is self-evident that no business man has ever honestly built up a large enterprise without applying some of the laws of scientific management. Such success is not a matter of chance, although chance may have furnished the opportunities that led to it. If it is not a matter of chance it must be a matter of scientific law, even though the man who has succeeded may not himself have seen a formulated statement of the particular laws that he intuitively applied. Generally, however, successful business men have had pretty clear conceptions of some of the laws of management.

The science of management has now developed sufficiently to have reached the stage when ridicule is heaped upon it. In this it repeats the history of all sciences. Fifteen years ago American farmers were laughing at professors of agriculture. It was a great joke to them to hear it gravely asserted that they did not understand the most important principles of scientific farming. Indeed it was laughable enough in itself, this new linking of the words science and farming. The laughter has ceased.

The Interstate Commerce Commission may wisely refuse to consider scientific management as a factor in rate making. Railway presidents may unwisely ridicule the claims made for the new science. The facts are that some civil engineers are applying the principles of scientific management in railway operation and construction with the same measure of success that has been secured in factories and in contract work. A knowledge of the success of these management engineers will spread slowly at first, but it will spread and the result will be the inevitable recognition of management engineering as a scientific profession of great importance.

THE MISTAKES OF THE EFFICIENCY MEN

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I

Extravagant Statements and Claims

Extravagant claims are of two kinds: (1) misrepresentation, either wilful or through ignorance, and, (2) extravagant in the sense that, even though possible of proof, their mere assertion creates a prejudice against them and thus prevents a fair trial of proof. And of the two, the second is the more insidious. A claim based upon misrepresentation or ignorance is proved to be untrue when the facts are known; and the discovery of the facts is in itself a most important step in an investigation into high costs or low efficiency. But a claim that, because of its extravagance, immediately calls for a flat denial, even though having foundation in fact, is usually thrown out without a hearing. To such claims on the part of efficiency men is due the apparent absence of agreement between them and those whom they would enlighten. The astonishing thing is that the efficiency men continue to make the same fatal mistake; and it is unjustifiable because it is so unnecessary. Examples of failure of efficiency schemes are legion.

An efficiency expert in the employ of a large concern had not been long on the job when he informed the manager in no uncertain terms what could be saved and how it could be done.[1] There was no doubt either as to the amount or the method. As action did not immediately follow, the efficiency man telegraphed the

[1] It is the practice of the Taylor group to make a preliminary survey at the request of the management interested in the application of the Taylor system, and to estimate as carefully and closely as the conditions permit the direction in which savings can be made and their probable extent. A study of their reports shows that this estimate is in all cases most conservative, that it is always given as an approximation, and that the expense to the management in time and money is at the same time carefully estimated. — Ed.

manager of the company urging him not to delay because every hour's delay meant an actual loss of one hundred dollars. Perhaps there was a leak somewhere in the plant; the management may not have been all that it should; and it is not unlikely that the amount named might have been saved through efficiency methods. But why was it necessary to invite criticism by making the bold claim and thus create a prejudice at a time when co-operation was the one important thing?

Another extravagant claim is that used to illustrate the alleged enormous waste in railway operation. It has done yeoman service on various occasions. It runs something like this: A locomotive in first class condition is but 50 per cent efficient if the track and road-bed have been allowed to deteriorate 50 per cent. If, in addition, the engineman has an efficiency of but 50 per cent, the result is to reduce the efficiency of the locomotive to 25 per cent. If, further, the fuel used has but half the heat units it should have, the combination of poor track, engineer and fuel results in an efficiency of but 12½ per cent, or a waste, or inefficiency, of 87½ per cent. The argument appears logical enough, but however compelling it may be to the layman, the railway manager knows that such conditions do not exist. Except in extreme cases no road-bed is allowed to deteriorate to such an extent as to carry but half the traffic it should. There cannot be such a combination of poor road-bed, locomotives and cars, men, fuel, etc., for the reason that long before these factors are allowed to deteriorate sufficiently to affect the net results materially, the remedy is discovered and applied. Locomotives are taken out of service and shopped before their condition has any appreciably damaging effect upon traffic. Engineers who are unable to meet their schedules must promptly give way to those who can.

It must be admitted that not unusually there is a basis in fact for many of the extravagant assertions of the efficiency men. It is because this is true that their claims not only do not accomplish what they are intended to, but, on the contrary, have the effect of obscuring actual conditions. That machine tools in most manufacturing and railway shops are not operated as efficiently as they should be, that the cost of maintenance is high, that the efficiency of the average workman is low, that fuel and supplies are being wasted, that locomotives and cars are not always repaired economically is unquestionably true. And it is important that the truth in this respect should be told. The plain truth, however, is sufficient; and although it requires frequent repetition, it needs no embellishment.

II

Neglect of the Human Element

Criticism of the theories of the efficiency men may be more or less a matter of opinion, but criticism of methods and practices, based on actual results, and backed up by the evidence of practical men who have intimate knowledge of the working of the so-called efficiency systems, ought to bear weight. And it is not to their credit that the efficiency men dismiss such evidence with scant consideration. Of the mistakes that have been made some are recognized so universally that it is to be wondered at that the efficiency men themselves fail to appreciate and correct them — so far reaching are they in their effects. Among these mistakes, perhaps none has been more apparent or more surely fatal than their failure to recognize the human element, in other words, their ignorance, at least in practice, of human nature. The millennium has been a long time coming, but most of us are willing to accept a little less than perfection, as we understand it, because we have learned by experience that perfection is an ideal to be striven for — seldom to be reached. There are practical and visionary idealists; the one appreciates the limitations of men and the frailties of human nature without sacrificing his ideals, the other, living apart in a world of fancy, can be satisfied only by perfection — and therefore forever remains unsatisfied.

This fundamental mistake is not confined to the relations of efficiency men to the rank and file of workmen; it extends alike to foremen, superintendents, managers and those in executive authority. How the efficiency men can expect to receive a favorable audience for presenting their cause after following the course they usually pursue is hard to imagine. What has been their general attitude toward these various classes? They have criticized railway executives because their philosophical discussions have not been taken seriously, forgetting that they are men of action rather than of words. They have charged railway and industrial managers with incapacity in dealing with intricate problems that have resulted from the growth and consequent complexity of their business, ignoring the power that comes only from intelligent and intimate knowledge of actual conditions. They have referred to superintendents, foremen and others in direct charge of operations as "of the old school," and to their management as "rutty," because they have depended on a practical experience and an ability to handle men rather than on artificial systems, to secure permanently good results, forgetting that the standards attained by such men have not been generally improved upon under so-called efficiency system. They have substituted for comparatively simple methods of determining costs and earnings, complicated and theoretical schemes without preparing the way for a clear understanding of their elements. In all of this, however worthy their object and however correct their reasoning, they have depended more on the force of logic to carry their plans to a successful conclusion than on a reasonable attitude which takes into account the elements of human nature that are common to the large majority of men. They have talked and written too much, and it is not surprising that the term "scientific management" has been given little serious thought in certain quarters.

One of the leading efficiency men has stated that "it is not men or materials, money, machines and methods that count, but more potently theories and principles." We shall not quarrel with them regarding the principles that underlie all successful industrial and railway management. Efficiency men are not alone in recognizing them. Abstract reasoning has its place, but in itself cannot make two blades of grass grow where one grew before, nor turn the wheels of industry. Great as imagination is, and however necessary a part it plays in broad and comprehensive plans for the improvement of the human race, it must be translated into the concrete before it is really vital. And it is not true that what is correct in theory is likewise always correct in practice. Scientific management of railways and industrial plants is not a system of philosophy; it is common sense applied to the working out of the problems that cannot be solved except through men — practical men, men who know.

A number of years ago one of the now leading efficiency engineers was engaged in a large industrial plant to introduce a piece work system. For two years he labored. Stop watch in hand, he timed the various operations and tabulated the results. His attitude toward the workmen was impersonal. He was a scientist (?) in his laboratory. He was a man apart. The men around him recognized him as such. Lacking their confidence, coöperation was impossible. But from the standpoint of the efficiency engineer this was unnecessary;[1] his faith was in his theories and principles. Consequently, when he appeared in the shop and began his observations, machines would often be slowed down with loss of output or speeded up with damage to tools. Every device known to the various trades was resorted to to block him at each turn. The result was that after two years of effort the establishment of a satisfactory piece work system was as far from realization as it had been when the task was started. Then a practical man was called in. He acquainted himself with the machines and their capacity. He mingled with the men and gained their confidence. He explained that the object in view was two-fold, to increase the output at a reduced cost per unit to the company, and at the same time to enable the men to earn more. Within six months he had accomplished results that the efficiency man had spent two years in an effort to secure. Why? Because he appreciated the importance of the man element.

Yet they tell us that practical men follow the rule-of-thumb, that they have not had the time and do not possess the ability to analyze closely the successive steps in the almost myriad

[1] Even a cursory study of the principles of the Taylor System should make it clear that coöperation, so far from being unnecessary, is absolutely fundamental and essential. — ED.

operations of a large shop, that because of a lack of scientific knowledge they are not competent to determine proper methods of work or secure the best results from operation. It is undoubtedly true that many practical men lack the peculiar qualities required by the efficiency engineer. Not a few successful men would be more successful if they possessed more fully the faculty of analysis and coördination and had a more lively appreciation of the theory of scientific management. But are the efficiency men assisting them in this direction? Rather, are they not practically ignoring the experience of practical men in their endeavors to establish the efficiency system, or to clarify the atmosphere surrounding it? Do they not give too little credit to the capacity of such men — inherent in some, acquired by many — to handle men, to convince them of their mistakes, to gain their sympathy and to establish that *esprit de corps* without which no organization is efficient? Under these conditions, efficiency engineers should not be surprised that practical men view with distrust their efforts in fields in which they have had no actual training. While there is perhaps no little prejudice back of such an attitude, it is nevertheless a real situation, and the success or failure of many an attempt in scientific management, as interpreted by the efficiency men, has been fore-shadowed by the extent to which the confidence has been secured of the men behind the guns.

An understanding of the psychology of the crowd as represented by a shop filled with workmen, possessed in large measure by most successful factory and railway managers, master mechanics, round house and shop foremen, cannot be replaced by a theory of management nor ignored with impunity in introducing efficiency methods. Of two men entering a shop apparently equally equipped, one was found to be analytical and critical both in respect to the details of his work and his fellow workmen, but lacking the magnetism that makes for leadership. The other, with less analytical ability and often wrong in his theories, possessed a personality that gave him an influence over the men around him. Which, naturally, became the leader, afterwards the foreman, then the superintendent? Such men, by the law of selection, represent the great majority of those who manage our railways and superintend our industrial and railway shops. Whatever their failings, they are to be reckoned with.

While many a shop foreman, superintendent or master mechanic may have no proper appreciation of the beauties of the philosophy of efficiency, may be unable to follow the line of reasoning of the efficiency men, may be mistaken in his belief that his men are more efficient than the " assays " have shown, and may have much to learn, he has usually reached his position because of certain qualifications possessed in greater measure by him than by the other men with whom he has been associated. And in introducing efficiency methods in his department it is a fatal mistake to omit the first essential, his good will, because almost invariably except through him the good will of the men cannot be secured. Too often the system is worked out with insufficient consideration being given to the men most closely affected; whose suggestions given with the best of intentions are ignored. Little pains is taken to explain the details of the system to those who must understand and favor it if it is to succeed. The word has gone out that the old system must give way to the new, and short shrift is given to the opposition. Thus it happens, that while this is farthest from their thought, the attitude of the efficiency man and that of the foreman and workmen are antagonistic. Lacking the initial meeting of the minds and agreement on essentials, efficiency plans are foreordained to fail.

The efficiency man is wise who gives greater place in his system to the greatest of all studies — the study of man.

III

Unscientific

In what respects are many of the efficiency men unscientific in their attitude and methods with reference to scientific management?

(1) In basing their conclusions on incorrect, insufficient, or immaterial data and in applying them to conditions which were absent in the initial investigation.

(2) In their impatience for results.

UNSCIENTIFIC METHODS OF DRAWING CONCLUSIONS

What is more common in their utterances than an imposing array of examples of extremely low efficiency, submitted as evidence that conditions call for heroic treatment, or of examples of high efficiency as a proof that their methods can alone bring order out of the chaos? A mere citation of disjointed facts, however, proves nothing. They are at best but half-truths, and as such are not only out of place in a scientific discussion of the questions under consideration, but are misleading. A disinterested seeker after the truth asks: "If the unsatisfactory conditions that have been described actually exist, are they due to a wrong system or to the absence of system; do they correctly represent average conditions, or are they only exceptional instances due to factors which are but local and transitory?"

Efficiency men claim to be scientific, as contrasted with practical men, who they say, follow the rule-of-thumb. But a scientist publishes his conclusions only when, after extended experiments and observations, he has found the evidence sufficient to warrant giving them publicity. He is no scientist who hastens into the limelight with evidence based on scattered examples, found amid varying conditions, and risks the odium of his co-workers by announcing premature conclusions.[1] Among reputable physicians, chemists, biologists and other scientists, it is customary to delay the announcement of important discoveries even far beyond the time which would seem under all the laws of logic to be required. The result is that when such an announcement is made it is backed up by a series of facts so closely related and so strongly fortified by innumerable examples bearing distinctly upon the question, that it is unusual, indeed, for it to require alteration.

Is it scientific to use as evidence cases of low efficiency and consequent high costs and unsatisfactory service, or of improve-

[1] Compare with this remark the Introduction to F. W. Taylor's "Art of Cutting Metals," in this volume, page 242. This paper was not published until twenty-six years of experiments had been made. Taylor's "Shop Management" was published thirty-three years after the methods described in it had begun to be practised. — ED.

ments that have followed the introduction of efficiency methods, without an equally fair statement of all the conditions that surround the operations? Or to search through the records for an especially poor performance to set alongside an especially good one, irrespective of the causes and the general tendency in either case? All thoughtful accountants appreciate how misleading statistical data may be unless all the concurrent factors are taken into consideration and proper allowances made for them. Whatever the unit of measurement, it is unsafe and improper to draw definite conclusions from too narrow a range of data.

A good record of one month may really be a poor one when all the facts are known. For example, in an industry where the different operations that precede the completion of a certain unit are scattered over a period of several months, the output during a particular month may, and usually does, bear no direct relation to the cost of operations during the month in question. In a shop building steam engines, machine tools, passenger cars, or similar equipment, requiring perhaps two months or more to assemble complete, it is the height of folly to assume that the cost of the operations in a given month divided by the output represents the cost per unit, and indicates whether the results are satisfactory or otherwise.

But the reader, left in such cases to his own resources to separate the real from the unreal, is either the willing and unsuspecting neophyte, accepting with wonderment the "evidence" which has no established basis, or is obliged to reject it all as unreal. It is unfair to those among the efficiency engineers who are scientists in the true meaning of the term. There is danger that their reputations will suffer and that their usefulness will be limited because of the unscientific deductions and absurd claims of the pseudo-scientists who ransack heaven and earth for comparisons that only serve to mislead those who are not in position to answer their arguments.

IV

Impatience for Results

Perhaps next to the failure of the efficiency men to appreciate the importance of the human element, the most certainly fatal mistake they have made is their impatience for results. This comes often after many of the obstacles to their success have been removed. It is not confined alone to them; many practical managers have failed for the same reason. But in introducing a system of work that involves features, which while the principles underlying them may not be new, are strange to the men who are most vitally affected, impatience can undo in short order what it has taken much time and expense to build up. If it is true that man is a suspicious animal, the average workman has his full share when a new system is introduced. If it has merit, its success should not be risked by premature announcements or by assuming an uncompromising attitude toward the men. If there is great waste in shop operation, and this has been going on many years, why the impatience to change it all in six months or a year?

Instead of establishing the system in one department, and proving its worth so unequivocally that it is demanded in other departments, certain efficiency men have urged its speedy extension to other departments, for the reason that unless it is introduced into all and recognized as the established system, there is danger that it will fail in the department in which it was initially instituted.[1] Such a necessity for its general extension is unworthy of any system which merits it. One of the most unfortunate results of the impatience that has caused shipwreck of so many well intentioned plans is the opportunity that is given to labor to organize and present a solid front of opposition to their establishment. It is both unnecessary and unscientific to demand or expect permanently satisfactory results in introducing scientific management without giving it time to grow in favor. If the

[1] It is the practice of the Taylor group to develop the system, department by department, mainly because this process facilitates the training of the permanent staff which is to extend and maintain the system after the expert is through.—Ed.

efficiency men have profited by this mistake, which has been the direct cause of many of their failures, they have gained much.

Just now scientific management is receiving consideration, either favorable or otherwise, in many quarters. There are those who believe that it offers nothing toward a solution of the problems that confront the industrial world. There are others who consider it a panacea for all our economic ills. Perhaps midway between these classes are those thoughtful men, some trained in the hard school of practical experience and possessing that true genius which is "an infinite capacity for taking pains," and others, with equal genius and with the instinct and training of the scientist, who are to be depended upon to extend the establishment of its principles. The purpose of scientific management is not to displace existing institutions. It is to perfect them. It has already been established on a much larger scale, although it may not bear the name, than many of the efficiency engineers are willing to admit. It is being further extended through patient study of existing conditions and a recognition of those factors which make for permanency. And while it is to be regretted that it is being retarded through misrepresentation and unfair criticism, it is an encouraging sign that there is a growing number of industrial and railway men of all ranks who are not blinded to its merits by the fulminations of the school of philosophers who may for the time being occupy the stage.

V

Neglect of Large Factors

A mistake common to the majority of the leading efficiency men, due perhaps to their zeal for a perfect control of the most minute details of every operation, is the neglect of certain large and important factors. The efficiency system cannot be separated from the other departments of shop activities, for the reason that it affects them all. It is not a branch grafted on to the main tree, but when properly introduced is a part of the body itself. There are many systems of shop management, which if installed in their entirety and strictly according to the ideas of their originators, are so complicated that it is manifestly impossible for a shop manager to familiarize himself with their details without neglecting many of the larger interests that have previously demanded his attention. Efficiency men, when given the opportunity to introduce scientific methods are often so intent upon proving the correctness of their theories that they, too, neglect the large factors. The difference is that they do so from choice, while the shop manager does so from necessity when he is required to adopt a system which he knows beforehand to be inadequate.

One of the most difficult problems confronting the efficiency engineer when he attempts to establish a new system of shop management is that of labor. The task of keeping the workmen contented without sacrificing profits is often the supreme test of a man responsible for their relations with the company. The successful manager is usually equal to this test. Efficiency men, however, are strangely blind to the attitude of labor toward a system which the men believe can tend only to reduce their earnings. Whether they are correct in this attitude or not does not alter the situation; they are a factor that cannot be ignored with impunity. An eminent efficiency engineer has said that "under efficiency operation strikes are inconceivable." It is because of this abounding faith in their theories that they fail to recognize the rumblings of discontent until the earthquake occurs.

Another factor all too frequently overlooked is the opportunity for increasing efficiency and reducing costs through simple expedients. Many a successful superintendent motive power has accomplished by the exercise of ingenuity and common sense what efficiency engineers, after exhaustive investigations and the introduction of theoretical schemes of doubtful value, have failed to bring about. Instead of following the line of least resistance they seem to prefer indirect and devious ways. Successful practical men know of better methods. If, for example, the cost of a certain class of locomotive repairs is running at, say, 12 cents a mile, the superintendent motive power may reach the conclusion that it is too high. It is not necessary that he should make an extended investigation in order to determine exactly how excessive his costs have been. Comparative figures interpreted by common sense and good judgment will tell him closely enough for his present purpose, and he may conclude that the cost should average not over nine cents. He has thus arrived, through the expedient of a simple determination of the possibilities, at a standard which may be termed a practicable ideal cost as distinguished from a theoretical ideal cost. Then by another simple calculation of charges and credits, and through comparative records by divisions, roundhouses and shops, the percentage of inefficiency may be determined and localized. If traceable to defective organization this can be corrected; if due to some inherent weakness in the design of any particular part of the locomotive, the part can be strengthened. This, of course, is not the "scientific" method, for it does not attempt to determine for every separate operation included in the cost of repairs the actual cost and efficiency. It is enough for all practicable purposes at this stage to know that the costs are computed on the same basis as formerly and that the figures for different periods are properly comparable, so that if costs are reduced from 12 to 9 cents a mile he is assured that it is not in the bookkeeping but that a reduction of 25 per cent has actually been made.

It is a fair statement that if in a certain instance locomotive or car repairs are excessive by, say, 30 per cent, it will cost less than half as much to save the first 20 per cent as to save the last 10 per cent. In fact, it is not unlikely that it would be practically impossible to secure the last 10 per cent, however elaborate a system might be installed. When the cost of a system is equivalent to the possible savings, it is, of course, only a useless burden. Proof that a high efficiency can be reached without recourse to a highly specialized system is found in the fact that it is recognized even by the scientific engineers that on many of the representative railways and in scores of industrial shops, low costs of operation accompanied by a high standard of service have been maintained for years. The possible economies through somewhat unscientific but effective calculations, comparisons and allowances, are enormous.

VI

Incompetent Counsel

When the efficiency men are charged with the mistake of giving incompetent counsel when their advice is sought, they are taken to task for ignoring one of the principles upon which their structure of shop management is built; for among the principles enumerated by Mr. Emerson in the series of articles current in the *Engineering Magazine*, not the least prominence is given to "competent counsel." We have read these and other similar effusions written by the chief efficiency men with the hope that much of what has been termed misunderstanding of their methods and theories might be cleared away. The particular series referred to has been hailed as a great work, and should contain the last word on scientific management. One has a right, therefore, to expect competent counsel at the hands of one speaking with such authority.

It has been correctly stated in the *Railway Age Gazette* on various occasions, that the interest in efficiency methods and scientific management has been increasing rapidly. It is a question, however, whether this is not in spite of, rather than because of, their exposition by certain efficiency men who are recognized as the leaders of the new philosophical school. Railway and industrial managers have been asking for bread and they have been given a stone. In the April number of the *Engineering Magazine*, is published the eleventh of the series of articles on "The Twelve Principles of Efficiency," entitled "The Ninth Principle — Standardized Conditions." Recognizing the importance of having conditions standardized and the economic loss due to the absence of standards, one naturally looks for valuable suggestions regarding this feature of scientific management. If there are any such suggestions in the article in question, a second and a third reading have failed to disclose them. As a philosophical dissertation, it may have a place, but as a contribution to the cause of scientific management it is sorely deficient. It opens with an interesting chapter from the life of the grub, followed by a comparison of the standards of the spider and the firefly with those of man, much to the detriment of the latter. Egypt and her pyramids have a place, then consideration is given to the evolution of the aeroplane. Efficiency principles are compared to the framework of a dome. The eight-hour train between New York and Chicago, and the three-day schedule for general repairs to a locomotive are prophesied, but no hint is given of the methods that will bring them into being. A large publishing house (which, if we read correctly between the lines, paid dearly for the introduction into its plant of a certain system of shop management) is put on the rack with other business men, who do not progress because of "imaginary specters that terrorize the soul." The article closes with an appeal for standardizing conditions in "our lives, our shops and our nation." To what extent competent counsel is given to those who are interested in standardizing conditions can be judged from the above summary.

This absence of competent counsel is not peculiar to the article in question; in a previous instalment of the same series on the subject of the first principle — "Clearly Defined Ideals," five pages are given over to a discussion of the seven ancient and the seven modern wonders of the world, and the seven American wonders. Nor is it peculiar to this series of articles. Ask one of the leading efficiency engineers to make a trip over a railway system, or make a study of a certain manufacturing plant, and to report upon the existing conditions and the possibilities. The larger part of such a report is likely to be akin to the conversation of Polonius, which Hamlet characterized as, "Words, words, words."

It is not unusual for certain efficiency men to refer the failure of their plans to a lack of coöperation on the part of those in authority. Is it not rather that the counselor has failed to give sound advice, and that consequently results have not squared with the promises? His attitude is too often that of one who never needs, but always gives counsel. That prejudice sometimes exists is no doubt true, but this is perhaps no more marked than that of many of the efficiency men toward the organization common to nearly all railway and industrial shops.

CONCLUSION

An effort has been made in these studies to point out for the advantage both of the efficiency men and of those who are interested, or should be, in the principles of scientific, or common sense, management, some of the chief mistakes that have figured in connection with its exposition and introduction. No claim is made to literary excellence in these discussions. They have been written by one who is himself deeply interested in the vital issues, and who recognizes and applies in his own field many of the principles that have been recommended, who is also familiar with extended efforts on the part of efficiency men to introduce systems of greater or less excellence. That they have made mistakes, however, need not be seriously regretted, providing profit is secured from them. The important thing is not to make the same blunders repeatedly. Those mistakes, which have seemed to the writer to be the most common, are: (1) Extravagant statements and claims, (2) the neglect of the human element, (3) the unscientific nature of many of their discussions and conclusions, (4) impatience for results, (5) neglect of large factors, (6) incompetent counsel. Of these the most surely fatal to the success of any advanced system of shop control are the neglect of the human element and impatience for results.

The nature of these observations has precluded the possibility of a recognition of the good that has been accomplished by the efficiency men, either directly or as a result of the publicity that has followed their utterances. The fact that we have charged them with many and serious errors has not blinded us to those features of their systems which have merit. It is not our province to refer to them here in detail; it would be unfair, however, and might lead to a misconception of the purpose of these studies to close them without a word of commendation for those among the efficiency men who have urged the principles of a common sense management in the face of almost insurmountable obstacles. It has been largely a campaign of education, and a call has gone out to operating men of all classes to seek a more intimate knowledge of the details of their business. The charge of gross inefficiency that has become a popular slogan, while much exaggerated, has led to systematic plans to reduce waste, and economies have already resulted, which had not been considered within the realm of possibility. From whatever point of view this science of management may be considered, and in all the heat of argument, it should be remembered that the law of the survival of the fittest holds in the economic as in the animal realm, and that because the principles of scientific management are vital to our industrial life, they have come to stay.

SCIENTIFIC MANAGEMENT

BY F. LINCOLN HUTCHINS

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PORT CHESTER, N. Y., February 5, 1911.

TO THE EDITOR OF THE RAILWAY AGE GAZETTE:

IT is inconceivable that the writer of "The Mistakes of Efficiency Men," in your issue of February 3, page 230, could ever have worked "with them," for he shows such a lamentable ignorance of their fundamental principles. Ordinarily such writers may be left to hang themselves, but as scientific management is now on the tapis and is so imperfectly understood in many quarters I feel impelled to criticise most of the article. Will the writer kindly give an instance which justifies his saying, "Failure of many of their theories when brought to the test of practical application"? The principles of scientific management are based on truisms and must be as true in practice as in theory; when failure occurs it will inevitably be found that it is caused by a violation of principle and not through fault of principle.

For a writer who claims to have "worked with them" to ask how the efficiency of a workman is arrived at, and then to go on and give an entirely erroneous account of how it is done is to say the least surprising. Cursory observation readily detects lost time in any operation; the operator stops to talk, to go on an errand, to look for material, etc. It is easy to see that waste motions are being made, that the speed is slow and to locate innumerable causes that restrict output, so that when he says: "Time studies are made, often with the assistance of a stop watch, by inexperienced men of little tact — students and others equally incapable," he writes himself down as one wholly misconceiving the situation. A trained observer, though he may know little about the particular operation which he is observing, can readily detect the wastes and keep account of them, the stop watch being merely an assistance in fixing the time; when this is done it is only the beginning of the making of a schedule upon which the efficiency shall be calculated. The fixing of that schedule must be the work of a person expert in the particular line in which the observation has been made and in which every consideration is given to the conditions surrounding the operation.

He also says that "men cannot be worked like machines," and this is where efficiency engineers maintain a strong position. Their object is not to increase the effort of the men, but on the other hand to decrease it, mixing a little brain with it to produce a greater output. The operator who has to run after the foreman for a job, for material, or for other things, has to work harder to turn out a satisfactory day's work. It is the object of the efficiency engineer to make the work easier for the operator. Take an actual illustration; an observer noticed that a machine was held up quite a time while two men laboriously put into place a heavy roll of paper; he studied out a plan whereby a new roll was ready to drop into the place of the preceding one as soon as it was empty; this increased the output and diminished the effort of the employee. It is an inexcusable error to maintain that efficiency engineers study to drive men to exhaustive effort; on the contrary they aim at assisting the men to secure greater output with diminished effort.

The trouble with the present system lies almost wholly with the management and not with the men; this is why scientific management is so effective. One of the tenets of scientific management is "immediate, reliable and adequate records." These are almost wholly lacking in railway service. Managers would be astonished could they but know the true facts as to their operations, but the reports, not records, which come to them do not give them. Were such records available it would be found that the estimates made by the efficiency engineers were much too low.

Again the writer exhibits his ignorance when he says: "It is not an unusual occurrence for superintendents and foremen to be misled by the evidence that John Brown and Tom Jones have increased their output from 70 to 100 per cent, into thinking that such results may be expected of all the men in their shop." If he had worked with efficiency engineers he should know that often a man of exceptional ability, the uncommon man, will attain an efficiency of 200 per cent [1] and keep it up day in and day out. When it is said that a concern or any part of it can be made 100 per cent efficient, it means that the average of all the men will be that, or in other words, that the output is equal to that which would be produced if every man worked to an even 100 per cent efficiency, a condition that will probably never occur. There will always be men of high and men of low efficiency. The fault with the present system is that high and low get the same rewards, which is neither just nor economical. The schedule always being made for the average man enables the uncommon man to realize much above the 100 per cent, and he should receive his reward in way of a bonus.

It would be interesting if the writer would name any efficiency engineer who ever contended that scientific management could be had without cost. It is one of their cardinal principles that to secure efficiency the cost of supervision must be increased and that the efficient man should receive more money. But the writer goes on to say that ultimately the men will beat the system; how this can be is past comprehension; if the operative delivers the output he gets his reward. How he is to get the reward without delivering the goods is not explained and would defy explanation.

Again, it is said that railways are different from other establishments. This is the old, old story: "That plan is excellent for so-and-so, but it would not work with me." All enterprises are alike in their fundamentals and the same underlying principles apply to all.

The writer refers to testimony taken before the Interstate Commerce Commission as to costs on some roads, but no efficiency engineer of any standing would claim that those costs were schedule costs. It might well be that roads with low costs were

[1] Two hundred per cent efficiency is possible by the Emerson method of calculating efficiency, but not by the Taylor method. In the Emerson method 100 per cent is a standard set much more roughly and approximately than by the Taylor method. — Ed.

as inefficient as those with high costs, the low cost being the result of exceptional favoring conditions. Only an exhaustive study and trial can determine the schedule in any particular case, for any particular road or any particular establishment.

The writer ends his article with these excellent sentences: "Successful railway operation is made up of a multiplicity of steps each carefully planned and carried out; that the problem is to control the parts in order that the whole may be controlled." These sentences are the alpha and omega of scientific management, but no one with a modicum of actual experience in connection with railway operation will hold for a moment that those steps are either planned or controlled. The methods in vogue have grown up like "Topsy," without coördination between parts and there is constant friction between departments and divisions. Each road has its heredity, which controls its system; each head of departments has his idiosyncracies resulting from his environment and the experience of the American Railway Association is sufficient proof that this heredity and environment are the most serious obstacles to placing the railway business on a scientific basis.

The writer says: "An efficiency engineer does not hesitate to promise almost immediate results." This is rank slander of the profession; perhaps the writer can name a single instance, but it is greatly to be doubted. It is a fact, however, that in anticipation of the taking hold of an efficiency task the men brace up and make a spurt to show that they are not so black as painted, but lacking systematic management it is something that cannot be continued.

As the real work of the efficiency engineer does not begin until he comes up against the "rutty" ways of the management, it follows that no immediate permanent results can be looked for or promised, and no one knows this better than the efficiency engineer. I appeal for fair play and the discussion of this question on fair grounds, with illustrative instances instead of a wholesale denouncement with misleading and erroneous statements of fact.

A PIECE RATE SYSTEM

BEING A STEP TOWARD PARTIAL SOLUTION OF THE LABOR PROBLEM

BY FREDERICK W. TAYLOR
GERMANTOWN, PHILADELPHIA, PA.

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INTRODUCTION

THE ordinary piece work system involves a permanent antagonism between employers and men, and a certainty of punishment for each workman who reaches a high rate of efficiency. The demoralizing effect of this system is most serious. Under it, even the best workmen are forced continually to act the part of hypocrites, to hold their own in the struggle against the encroachments of their employers.

The system introduced by the writer, however, is directly the opposite, both in theory and in its results. It makes each workman's interests the same as that of his employer, pays a premium for high efficiency, and soon convinces each man that it is for his permanent advantage to turn out each day the best quality and maximum quantity of work.

The writer has endeavored in the following pages to describe the system of management introduced by him in the works of the Midvale Steel Company, of Philadelphia, which has been employed by them during the past ten years with the most satisfactory results.

The system consists of three principal elements: —

(1) An elementary rate-fixing department.

(2) The differential rate system of piece work.

(3) What he believes to be the best method of managing men who work by the day.

Elementary rate-fixing differs from other methods of making piece work prices in that a careful study is made of the time required to do each of the many elementary operations into which the manufacturing of an establishment may be analyzed or divided. These elementary operations are then classified, recorded, and indexed, and when a piece work price is wanted for work, the job is first divided into its elementary operations, the time required to do each elementary operation is found from the records, and the total time for the job is summed up from these data. While this method seems complicated at the first glance, it is, in fact, far simpler and more effective than the old method of recording the time required to do whole jobs of work, and then, after looking over the records of similar jobs, guessing at the time required for any new piece of work.

The differential rate system of piece work consists briefly in offering two different rates for the same job; a high price per piece, in case the work is finished in the shortest possible time and in perfect condition, and a low price, if it takes a longer time to do the job, or if there are any imperfections in the work. (The high rate should be such that the workman can earn more per day than is usually paid in similar establishments.) This is directly the opposite of the ordinary plan of piece work, in which the wages of the workmen are reduced when they increase their productivity.

The system by which the writer proposes managing the men who are on day work consists in paying *men* and not *positions*. Each man's wages, as far as possible, are fixed according to the skill and energy with which he performs his work, and not according to the position which he fills. Every endeavor is made to stimulate each man's personal ambition. This involves keeping systematic and careful records of the performance of each man, as to his punctuality, attendance, integrity, rapidity, skill, and accuracy, and a readjustment from time to time of the wages paid him, in accordance with this record.

The advantages of this system of management are: —

First. That the manufactures are produced cheaper under it, while at the same time the workmen earn higher wages than are usually paid.

Second. Since the rate-fixing is done from accurate knowledge instead of more or less by guess-work, the motive for holding back on work, or "soldiering," and endeavoring to deceive the employers as to the time required to do work is entirely removed, and with it the greatest cause for hard feelings and war between the management and the men.

Third. Since the basis from which piece work as well as day rates are fixed is that of exact observation, instead of being founded upon accident or deception, as is too frequently the case under ordinary systems, the men are treated with greater uniformity and justice, and respond by doing more and better work.

Fourth. It is for the common interest of both the management and the men to coöperate in every way, so as to turn out each day the maximum quantity and best quality of work.

Fifth. The system is rapid, while other systems are slow, in attaining the maximum productivity of each machine and man; and when this maximum is once reached, it is automatically maintained by the differential rate.

Sixth. It automatically selects and attracts the best men for each class of work, and it develops many first-class men who would otherwise remain slow or inaccurate, while at the same time it discourages and sifts out men who are incurably lazy or inferior.

Finally. One of the chief advantages derived from the above effects of the system is that it promotes a most friendly feeling between the men and their employers, and so renders labor unions and strikes unnecessary.

There has never been a strike under the differential rate system of piece work, although it has been in operation for the past ten years in the steel business, which has been during this period more subject to strikes and labor troubles than almost any other industry. In describing the above system of management, the writer has been obliged to refer to other piece work methods, and to indicate briefly what he believes to be their shortcomings.

As but few will care to read the whole paper, the following index to its contents is given: —

INDEX

1. Capital demands fully twice the return for money placed in manufacturing enterprises that it does for real estate or transportation ventures. And this probably represents the difference in the risk between these classes of investments.

2. Among the risks of a manufacturing business, by far the greatest is that of bad management; and of the three managing departments, the commercial, the financiering, and the productive, the latter, in most cases, receives the least attention from those that have invested their money in the business, and contains the greatest elements of risk. This risk arises not so much from the evident mismanagement, which plainly discloses itself through occasional strikes and similar troubles, as from the daily more insidious and fatal failure on the part of the superintendents to secure anything even approaching the maximum work from their men and machines.

3. It is not unusual for the manager of a manufacturing business to go most minutely into every detail of the buying and selling and financiering, and arrange every element of these branches in the most systematic manner, and according to principles that have been carefully planned to insure the business against almost any contingency which may arise, while the manufacturing is turned over to a superintendent or foreman, with little or no restrictions as to the principles and methods which he is to pursue, either in the management of his men or the care of the company's plant.

4. Such managers belong distinctly to the old school of manufacturers; and among them are to be found, in spite of their lack of system, many of the best and most successful men of the country. They believe in men, not in methods, in the management of their shops; and what they would call system in the office and sales departments, would be called red tape by them in the factory. Through their keen insight and knowledge of character they are able to select and train good superintendents,

who in turn secure good workmen; and frequently the business prospers under this system (or rather, lack of system) for a term of years.

5. The modern manufacturer, however, seeks not only to secure the best superintendents and workmen, but to surround each department of his manufacture with the most carefully woven net-work of system and method, which should render the business, for a considerable period, at least, independent of the loss of any one man, and frequently of any combination of men.

6. It is the lack of this system and method which, in the judgment of the writer, constitutes the greatest risk in manufacturing; placing, as it frequently does, the success of the business at the hazard of the health or whims of a few employees.

7. Even after fully realizing the importance of adopting the best possible system and methods of management for securing a proper return from employees and as an insurance against strikes and the carelessness and laziness of men, there are difficulties in the problem of selecting methods of management which shall be adequate to the purpose, and yet be free from red tape, and inexpensive.

8. The literature on the subject is meagre, especially that which comes from men of practical experience and observation. And the problem is usually solved, after but little investigation, by the adoption of the system with which the managers are most familiar, or by taking a system which has worked well in similar lines of manufacture.

9. Now, among the methods of management in common use there is certainly a great choice; and before describing the "differential rate" system it is desirable to briefly consider the more important of the other methods.

10. The simplest of all systems is the "day work" plan, in which the employees are divided into certain classes, and a standard rate of wages is paid to each class of men; the laborers all receiving one rate of pay, the machinists all another rate, and the engineers all another, etc. The men are paid according to the position which they fill, and not according to their individual character, energy, skill, and reliability.

11. The effect of this system is distinctly demoralizing and levelling; even the ambitious men soon conclude that since there is no profit to them in working hard, the best thing for them to do is to work just as little as they can and still keep their position. And under these conditions the invariable tendency is to drag them all down even below the level of the medium.

12. The proper and legitimate answer to this herding of men together into classes, regardless of personal character and performance, is the formation of the labor union, and the strike, either to increase the rate of pay and improve conditions of employment, or to resist the lowering of wages and other encroachments on the part of employers.

13. The necessity for the labor union,[1] however, disappears when *men* are paid, and not *positions;* that is, when the employers take pains to study the character and performance of each of their employees and pay them accordingly, when accurate records are kept of each man's attendance, punctuality, the amount and quality of work done by him, and his attitude towards his employers and fellow workmen.

As soon as the men recognize that they have free scope for the exercise of their proper ambition, that as they work harder and better their wages are from time to time increased, and that they are given a better class of work to do — when they recognize this, the best of them have no use for the labor union.

14. Every manufacturer must from necessity employ a certain amount of day labor which cannot come under the piece work system; and yet how few employers are willing to go to the trouble and expense of the slight organization necessary to handle their men in this way? How few of them realize that, by the employment of an extra clerk and foreman, and a simple system of labor returns, to record the performance and readjust the wages of their men, so as to stimulate their personal ambition, the output of a gang of twenty or thirty men can be readily

[1] For another view of the relation of scientific management to the labor unions, see C. B. Thompson's "The Relation of Scientific Management to the Wage Problem," p. 706, and F. T. Carlton's "Scientific Management and the Wage-Earner," p. 721. — ED.

doubled in many cases, and at a comparatively slight increase of wages per capita!

15. The clerk in the factory is the particular horror of the old-style manufacturer. He realizes the expense each time that he looks at him, and fails to see any adequate return; yet by the plan here described the clerk becomes one of the most valuable agents of the company.

16. If the plan of grading labor and recording each man's performance is so much superior to the old day work method of handling men, why is it not all that is required? Because no foreman can watch and study all of his men all of the time, and because any system of laying out and apportioning work, and of returns and records, which is sufficiently elaborate to keep proper account of the performance of each workman, is more complicated than piece work. It is evident that that system is the best which, in attaining the desired result, presents in the long run the course of least resistance.

17. The inherent and most serious defect of even the best managed day work lies in the fact that there is nothing about the system that is self-sustaining. When once the men are working at a rapid pace, there is nothing but the constant, unremitting watchfulness and energy of the management to keep them there; while with every form of piece work each new rate that is fixed insures a given speed for another section of work, and to that extent relieves the foreman from worry.

18. From the best type of day work to ordinary piece work the step is a short one. With good day work the various operations of manufacturing should have been divided into small sections or jobs, in order to properly gauge the efficiency of the men; and the quickest time should have been recorded in which each operation has been performed. The change from paying by the hour to paying by the job is then readily accomplished.

19. The theory upon which the ordinary system of piece work operates to the benefit of the manufacturer is exceedingly simple. Each workman, with a definite price for each job before him, contrives a way of doing it in a shorter time, either by working harder or by improving his method; and he thus makes a larger

profit. After the job has been repeated a number of times at the more rapid rate, the manufacturer thinks that he should also begin to share in the gain, and therefore reduces the price of the job to a figure at which the workman, although working harder, earns, perhaps, but little more than he originally did when on day work.

20. The actual working of the system, however, is far different. Even the most stupid man, after receiving two or three piece work " cuts " as a reward for his having worked harder, resents this treatment and seeks a remedy for it in the future. Thus begins a war, generally an amicable war, but none the less a war, between the workmen and the management. The latter endeavors by every means to induce the workmen to increase the output, and the men gauge the rapidity with which they work, so as never to earn over a certain rate of wages, knowing that if they exceed this amount the piece work price will surely be cut, sooner or later.

21. But the war is by no means restricted to piece work. Every intelligent workman realizes the importance, to his own interest, of starting in on each new job as slowly as possible. There are few foremen or superintendents who have anything but a general idea as to how long it should take to do a piece of work that is new to them. Therefore, before fixing a piece work price, they prefer to have the job done for the first time by the day. They watch the progress of the work as closely as their other duties will permit, and make up their minds how quickly it can be done. It becomes the workman's interest then to go just as slowly as possible, and still convince his foreman that he is working well.

22. The extent to which, even in our largest and best-managed establishments, this plan of holding back on the work — " marking time," or " soldiering," as it is called — is carried on by the men, can scarcely be understood by one who has not worked among them. It is by no means uncommon for men to work at the rate of one-third, or even one-quarter, their maximum speed, and still preserve the appearance of working hard. And when a rate has once been fixed on such a false basis, it is easy for the

men to nurse successfully " a soft snap " of this sort through a term of years, earning in the meanwhile just as much wages as they think they can without having the rate cut.

23. Thus arises a system of hypocrisy and deceit on the part of the men which is thoroughly demoralizing, and which has led many workmen to regard their employers as their natural enemies, to be opposed in whatever they want, believing that whatever is for the interest of the management must necessarily be to their detriment.

24. The effect of this system of piece work on the character of the men is, in many cases, so serious as to make it doubtful whether, on the whole, well-managed day work is not preferable.

25. There are several modifications of the ordinary method of piece work which tend to lessen the evils of the system, but I know of none that can eradicate the fundamental causes for war, and enable the managers and the men to heartily coöperate in obtaining the maximum product from the establishment. It is the writer's opinion, however, that the differential rate system of piece work, which will be described later, in most cases entirely harmonizes the interests of both parties.

26. One method of temporarily relieving the strain between workmen and employers consists in reducing the price paid for work, and at the same time guaranteeing the men against further reduction for a definite period. If this period be made sufficiently long, the men are tempted to let themselves out and earn as much money as they can, thus " spoiling " their own job by another " cut " in rates when the period has expired.

27. Perhaps the most successful modification of the ordinary system of piece work is the " gain sharing plan." This was invented by Mr. Henry R. Towne, in 1886, and has since been extensively and successfully applied by him in the Yale & Towne Manufacturing Co., at Stamford, Conn. It was admirably described in a paper which he read before this Society in 1888. This system of paying men is, however, subject to the serious, and I think fatal, defect that it does not recognize the personal merit of each workman; the tendency being rather to herd men

together and promote trades unionism, than to develop each man's individuality.

28. A still further improvement of this method was made by Mr. F. A. Halsey, and described by him in a paper entitled "The Premium Plan of Paying for Labor," and presented to this Society in 1891.[1] Mr. Halsey's plan allows free scope for each man's personal ambition, which Mr. Towne's does not.

29. Messrs. Towne and Halsey's plans consist briefly in recording the cost of each job as a starting-point at a certain time; then, if, through the effort of the workmen in the future, the job is done in a shorter time and at a lower cost, the gain is divided among the workmen and the employer in a definite ratio, the workmen receiving, say, one-half, and the employer one-half.

30. Under this plan, if the employer lives up to his promise, and the workman has confidence in his integrity, there is the proper basis for coöperation to secure sooner or later a large increase in the output of the establishment.

Yet there still remains the temptation for the workman to "soldier" or hold back while on day work, which is the most difficult thing to overcome. And in this as well as in all the systems heretofore referred to, there is the common defect: that the starting-point from which the first rate is fixed is unequal and unjust. Some of the rates may have resulted from records obtained when a good man was working close to his maximum speed, while others are based on the performance of a medium man at one-third or one-quarter speed. From this follows a great inequality and injustice in the reward even of the same man when at work on different jobs. The result is far from a realization of the ideal condition in which the same return is uniformly received for a given expenditure of brains and energy. Other defects in the gain sharing plan, and which are corrected by the differential rate system, are: —

(1) That it is slow and irregular in its operation in reducing costs, being dependent upon the whims of the men working under it.

[1] See *Transactions of the American Society of Mechanical Engineers*, Vol. 12, p. 755. — ED.

(2) That it fails to especially attract first class men and discourage inferior men.

(3) That it does not automatically insure the maximum output of the establishment per man and machine.

31. Coöperation, or profit sharing, has entered the mind of every student of the subject as one of the possible and most attractive solutions of the problem; and there have been certain instances, both in England and France, of at least a partial success of coöperative experiments.

So far as I know, however, these trials have been made either in small towns, remote from the manufacturing centres, or in industries which in many respects are not subject to ordinary manufacturing conditions.

32. Coöperative experiments have failed, and, I think, are generally destined to fail, for several reasons, the first and most important of which is that no form of coöperation has yet been devised in which each individual is allowed free scope for his personal ambition. This always has been and will remain a more powerful incentive to exertion than a desire for the general welfare. The few misplaced drones, who do the loafing and share equally in the profits with the rest, under coöperation are sure to drag the better men down toward their level.

33. The second and almost equally strong reason for failure lies in the remoteness of the reward. The average workman (I don't say all men) cannot look forward to a profit which is six months or a year away. The nice time which they are sure to have to-day, if they take things easily, proves more attractive than hard work, with a possible reward to be shared with others six months later.

34. Other and formidable difficulties in the path of coöperation are the equitable division of the profits, and the fact that, while workmen are always ready to share the profits, they are neither able nor willing to share the losses. Further than this, in many cases, it is neither right nor just that they should share either in the profits or the losses, since these may be due in great part to causes entirely beyond their influence or control, and to which they do not contribute.

35. When we do recognize the real antagonism that exists between the interests of the men and their employers, under all of the systems of piece work in common use; and when we remember the apparently irreconcilable conflict implied in the fundamental and perfectly legitimate aims of the two: namely, on the part of the men: —

THE UNIVERSAL DESIRE TO RECEIVE THE LARGEST POSSIBLE WAGES FOR THEIR TIME.

And on the part of the employers: —

THE DESIRE TO RECEIVE THE LARGEST POSSIBLE RETURN FOR THE WAGES PAID.

What wonder that most of us arrive at the conclusion that no system of piece work can be devised which shall enable the two to coöperate without antagonism, and to their mutual benefit?

36. Yet it is the opinion of the writer, that even if a system has not already been found which harmonizes the interests of the two, still the basis for harmonious coöperation lies in the two following facts: —

First. That the workmen in nearly[1] every trade can and will materially increase their present output per day, providing they are assured of a permanent and larger return for their time than they have heretofore received.

Second. That the employers can well afford to pay higher wages per piece even permanently, providing each man and machine in the establishment turns out a proportionately larger amount of work.

37. The truth of the latter statement arises from the well-recognized fact that, in most lines of manufacture, the indirect expenses equal or exceed the wages paid directly to the workmen, and that these expenses remain approximately constant, whether the output of the establishment is great or small.

[1] The writer's knowledge of the speed attained in the manufacture of textile goods is very limited. It is his opinion, however, that owing to the comparative uniformity of this class of work, and the enormous number of machines and men engaged on similar operations, the maximum output per man and machine is more nearly realized in this class of manufactures than in any other. If this is the case, the opportunity for improvement does not exist to the same extent here as in other trades. Some illustrations of the possible increase in the daily output of men and machines are given in paragraphs 78 to 82.

From this it follows that it is always cheaper to pay higher wages to the workmen when the output is proportionately increased; the diminution in the indirect portion of the cost per piece being greater than the increase in wages. Many manufacturers, in considering the cost of production, fail to realize the effect that the *volume of output has on the cost.* They lose sight of the fact that taxes, insurance, depreciation, rent, interest, salaries, office expenses, miscellaneous labor, sales expenses, and frequently the cost of power (which in the aggregate amount to as much as wages paid to workmen) remain about the same whether the output of the establishment is great or small.

38. In our endeavor to solve the piece work problem by the application of the two fundamental facts above referred to, let us consider the obstacles in the path of harmonious coöperation, and suggest a method for their removal.

39. The most formidable obstacle is the lack of knowledge on the part of both the men and the management (but chiefly the latter) of the quickest time in which each piece of work can be done; or, briefly, the lack of accurate time-tables for the work of the place.

40. The remedy for this trouble lies in the establishment in every factory of a proper rate-fixing department; a department which shall have equal dignity and command equal respect with the engineering and managing departments, and which shall be organized and conducted in an equally scientific and practical manner.

41. The rate-fixing, as at present conducted, even in our best-managed establishments, is very similar to the mechanical engineering of fifty or sixty years ago. Mechanical engineering at that time consisted in imitating machines which were in more or less successful use, or in guessing at the dimensions and strength of the parts of a new machine; and as the parts broke down or gave out, in replacing them with stronger ones. Thus each new machine presented a problem almost independent of former designs, and one which could only be solved by months or years of practical experience and a series of break-downs.

Modern engineering, however, has become a study, not of individual machines, but of the resistance of materials, the fundamental principles of mechanics, and of the elements of design.

42. On the other hand, the ordinary rate-fixing (even the best of it), like the old-style engineering, is done by a foreman or superintendent, who, with the aid of a clerk, looks over the record of the time in which a whole job was done as nearly like the new one as can be found, and then guesses at the time required to do the new job. No attempt is made to analyze and time each of the classes of work, or elements of which a job is composed; although it is a far simpler task to resolve each job into its elements, to make a careful study of the quickest time in which each of the elementary operations can be done, and then to properly classify, tabulate, and index this information, and use it when required for rate-fixing, than it is to fix rates, with even an approximation to justice, under the common system of guessing.

43. In fact, it has never occurred to most superintendents that the work of their establishments consists of various combinations of elementary operations which can be timed in this way; and a suggestion that this is a practical way of dealing with the piece work problem usually meets with derision, or, at the best, with the answer that "It might do for some simple business, but my work is entirely too complicated."

44. Yet this elementary system of fixing rates has been in successful operation for the past ten years, on work complicated in its nature, and covering almost as wide a range of variety as any manufacturing that the writer knows of. In 1883, while foreman of the machine shop of the Midvale Steel Company of Philadelphia, it occurred to the writer that it was simpler to time each of the elements of the various kinds of work done in the place, and then find the quickest time in which each job could be done, by summing up the total times of its component parts, than it was to search through the records of former jobs, and guess at the proper price. After practising this method of rate-fixing himself for about a year, as well as circumstances would permit, it became evident that the system was a success. The

writer then established the rate-fixing department, which has given out piece work prices in the place ever since.

45. This department far more than paid for itself from the very start; but it was several years before the full benefits of the system were felt, owing to the fact that the best methods of making and recording time observations of work done by the men, as well as of determining the maximum capacity of each of the machines in the place, and of making working-tables and time-tables were not at first adopted.

46. Before the best results were finally attained in the case of work done by metal-cutting tools, such as lathes, planers, boring mills, etc., a long and expensive series of experiments was made, to determine, formulate, and finally practically apply to each machine the law governing the proper cutting speed of tools; namely, the effect on the cutting speed of altering any one of the following variables: the shape of the tool (*i. e.*, lip angle, clearance angle, and the line of the cutting edge), the duration of the cut, the quality or hardness of the metal being cut, the depth of the cut, and the thickness of the feed or shaving.[1]

47. It is the writer's opinion that a more complicated and difficult piece of rate-fixing could not be found than that of determining the proper price for doing all kinds of machine work on miscellaneous steel and iron castings and forgings, which vary in their chemical composition from the softest iron to the hardest tool steel. Yet this problem was solved through the rate-fixing department and the "differential rate," with the final result of completely harmonizing the men and the management, in place of the constant war that existed under the old system. At the same time the quality of the work was improved, and the output of the machinery and the men was doubled, and, in many cases, trebled. At the start there was naturally great opposition to the rate-fixing department, particularly to the man who was taking time observations of the various elements of the work; but when the men found that rates were fixed without regard to

[1] See F. W. Taylor's "The Art of Cutting Metals," in *Transactions of The American Society of Mechanical Engineers*, Vol. 28, p. 31. Published by same Society in book form, 1907. — Ed.

the records of the quickest time in which they had actually done each job, and that the knowledge of the department was more accurate than their own, the motive for hanging back or "soldiering" on this work ceased, and with it the greatest cause for antagonism and war between the men and the management.

48. As an illustration of the great variety of work to which elementary rate-fixing has already been successfully applied the writer would state that, while acting as general manager of two large sulphite pulp mills, he directed the application of piece work to all of the complicated operations of manufacturing, throughout one of these mills, by means of elementary rate-fixing, with the result, within eighteen months, of more than doubling the output of the mill.

The difference between elementary rate-fixing and the ordinary plan can perhaps be best explained by a simple illustration. Suppose the work to be planing a surface on a piece of cast iron. In the ordinary system the rate-fixer would look through his records of work done by the planing machine, until he found a piece of work as nearly as possible similar to the proposed job, and then guess at the time required to do the new piece of work. Under the elementary system, however, some such analysis as the following would be made: —

Work done by man	Minutes
Time to lift piece from floor to planer table..............	———
Time to level and set work true on table................	———
Time to put on stops and bolts.........................	———
Time to remove stops and bolts........................	———
Time to remove piece to floor..........................	———
Time to clean machine...............................	———
Work done by machine	**Minutes**
Time to rough off cut $\frac{3}{4}$ in. thick, 4 feet long, $2\frac{1}{2}$ ins. wide.	———
Time to rough off cut $\frac{1}{8}$ in. thick, 3 feet long, 12 ins. wide, etc.	———
Time to finish cut 4 feet long, $2\frac{1}{2}$ ins. wide...............	———
Time to finish cut 3 feet long, 12 ins. wide, etc..........	———
Total	———
Add ——— per cent for unavoidable delays	———

It is evident that this job consists of a combination of elementary operations, the time required to do each of which can be readily determined by observation.

This exact combination of operations may never occur again, but elementary operations similar to these will be performed in differing combinations almost every day in the same shop.

A man whose business it is to fix rates soon becomes so familiar with the time required to do each kind of elementary work performed by the men that he can write down the time from memory.

In the case of that part of the work which is done by the machine the rate-fixer refers to tables which are made out for each machine, and from which he takes the time required for any combination of breadth, depth, and length of cut.

49. While, however, the accurate knowledge of the quickest time in which work can be done, obtained by the rate-fixing department and accepted by the men as standard, is the greatest and most important step towards obtaining the maximum output of the establishment, it is one thing to know how much work can be done in a day, and an entirely different matter to get even the best men to work at their fastest speed or anywhere near it.

50. The means which the writer has found to be by far the most effective in obtaining the maximum output of a shop, and which, so far as he can see, satisfies the legitimate requirements, both of the men and the management, is the *differential rate system of piece work.*

This consists briefly in paying a higher price per piece, or per unit, or per job, if the work is done in the shortest possible time, and without imperfections, than is paid if the work takes a longer time or is imperfectly done.

51. To illustrate: Suppose 20 units or pieces to be the largest amount of work of a certain kind that can be done in a day. Under the differential rate system, if a workman finishes 20 pieces per day, and all of these pieces are perfect, he receives, say, 15 cents per piece, making his pay for the day 15 × 20 = $3. If, however, he works too slowly and turns out, say, only 19 pieces, then, instead of receiving 15 cents per piece he gets only 12 cents per piece, making his pay for the day 12 × 19 = $2.28, instead of $3 per day.

If he succeeds in finishing 20 pieces, some of which are imperfect, then he should receive a still lower rate of pay, say, 10 cents or 5 cents per piece, according to circumstances, making his pay for the day $2, or only $1, instead of $3.

52. It will be observed that this style of piece work is directly the opposite of the ordinary plan. To make the difference between the two methods more clear: Supposing, under the ordinary system of piece work, that the workman has been turning out 16 pieces per day, and has received 15 cents per piece, then his day's wages would be 15 × 16 = $2.40. Through extra exertion he succeeds in increasing his output to 20 pieces per day, and thereby increases his pay to 15 × 20 = $3. The employer, under the old system, however, concludes that $3 is too much for the man to earn per day, since other men are only getting from $2.25 to $2.50, and therefore cuts the price from 15 cents per piece to 12 cents, and the man finds himself working at a more rapid pace, and yet earning only the same old wages, 12 × 20 = $2.40 per day. What wonder that men do not care to repeat this performance many times?

53. Whether coöperation, the differential plan, or some other form of piece work be chosen in connection with elementary rate-fixing as the best method of working, there are certain fundamental facts and principles which must be recognized and incorporated in any system of management, before true and lasting success can be attained; and most of these facts and principles will be found to be not far removed from what the strictest moralists would call justice.

54. The most important of these facts is that MEN WILL NOT DO AN EXTRAORDINARY DAY'S WORK FOR AN ORDINARY DAY'S PAY; and any attempt on the part of employers to get the best work out of their men and give them the standard wages paid by their neighbors will surely be, and ought to be, doomed to failure.

55. Justice, however, not only demands for the workman an increased reward for a large day's work, but should compel him to suffer an appropriate loss in case his work falls off either in quantity or quality. It is quite as important that the deductions for bad work should be just, and graded in proportion to

the shortcomings of the workman, as that the reward should be proportional to the work done.

The fear of being discharged, which is practically the only penalty applied in many establishments, is entirely inadequate to producing the best quantity and quality of work; since the workmen find that they can take many liberties before the management makes up its mind to apply this extreme penalty.

56. It is clear that the differential rate satisfies automatically, as it were, the above conditions of properly graded rewards and deductions. Whenever a workman works for a day (or even a shorter period) at his maximum, he receives under this system unusually high wages; but when he falls off either in quantity or quality from the highest rate of efficiency his pay falls below even the ordinary.[1]

57. The lower differential rate should be fixed at a figure which will allow the workman to earn scarcely an ordinary day's pay when he falls off from his maximum pace, so as to give him every inducement to work hard and well.

58. The exact percentage beyond the usual standard which must be paid to induce men to work to their maximum varies with different trades and with different sections of the country. And there are places in the United States where the men (generally speaking) are so lazy and demoralized that no sufficient inducement can be offered to make them do a full day's work.[2]

59. It is not, however, sufficient that each workman's ambition should be aroused by the prospect of larger pay at the end of even a comparatively short period of time. The stimulus to maximum exertion should be a daily one.

This involves such vigorous and rapid inspection and returns as to enable each workman in most cases to know each day the exact result of his previous day's work — *i. e.*, whether he has succeeded in earning his maximum pay, and exactly what his

[1] In practice the low rate is usually set at, or a trifle above, the prevailing rate in the vicinity; while the high rate is, of course, considerably above the customary rate. — Ed.

[2] This is well illustrated by the fact that the same company which finds the differential rate working to advantage in Philadelphia is unable to apply it to the class of men working in one of its plants in Chicago. — Ed.

losses are for careless or defective work. Two-thirds of the moral effect, either of a reward or penalty, is lost by even a short postponement.

60. It will again be noted that the differential rate system forces this condition both upon the management and the workmen, since the men, while working under it, are above all anxious to know at the earliest possible minute whether they have earned their high rate or not. And it is equally important for the management to know whether the work has been properly done.

61. As far as possible each man's work should be inspected and measured separately, and his pay and losses should depend upon his individual efforts alone. It is, of course, a necessity that much of the work of manufacturing — such, for instance, as running roll-trains, hammers, or paper machines — should be done by gangs of men who coöperate to turn out a common product, and that each gang of men should be paid a definite price for the work turned out, just as if they were a single man.

In the distribution of the earnings of a gang among its members, the percentage which each man receives should, however, depend not only upon the kind of work which each man performs, but upon the accuracy and energy with which he fills his position.

In this way the personal ambition of each of a gang of men may be given its proper scope.

62. Again, we find the differential rate acting as a most powerful lever to force each man in a gang of workmen to do his best; since if, through the carelessness or laziness of any one man, the gang fails to earn its high rate, the drone will surely be obliged by his companions to do his best the next time or else get out.

63. A great advantage of the differential rate system is that it quickly drives away all inferior workmen, and attracts the men best suited to the class of work to which it is applied; since none but really good men can work fast enough and accurately enough to earn the high rate; and the low rate should be made so small as to be unattractive even to an inferior man.

64. If for no other reason than it secures to an establishment a quick and active set of workmen, the differential rate is a valuable aid, since men are largely creatures of habit; and if the

piece workers of a place are forced to move quickly and work hard the day workers soon get into the same way, and the whole shop takes on a more rapid pace.

65. The greatest advantage, however, of the differential rate for piece work, in connection with a proper rate-fixing department, is that together they produce the proper mental attitude on the part of the men and the management toward each other. In place of the indolence and indifference which characterize the workmen of many day work establishments, and to a considerable extent also their employers; and in place of the constant watchfulness, suspicion, and even antagonism with which too frequently the men and the management regard each other, under the ordinary piece work plan, both sides soon appreciate the fact that with the differential rate it is their common interest to coöperate to the fullest extent, and to devote every energy to turning out daily the largest possible output. This common interest quickly replaces antagonism, and establishes a most friendly feeling.

66. Of the two devices for increasing the output of a shop, the differential rate and the scientific rate-fixing department, the latter is by far the more important. The differential rate is invaluable at the start, as a means of convincing men that the management is in earnest in its intention of paying a premium for hard work; and it at all times furnishes the best means of maintaining the top notch of production; but when, through its application, the men and the management have come to appreciate the mutual benefit of harmonious coöperation and respect for each other's rights, it ceases to be an absolute necessity. On the other hand, the rate-fixing department, for an establishment doing a large variety of work, becomes absolutely indispensable. The longer it is in operation the more necessary it becomes.

67. Practically, the greatest need felt in an establishment wishing to start a rate-fixing department is the lack of data as to the proper rate of speed at which work should be done.

There are hundreds of operations which are common to most large establishments; yet each concern studies the speed problem for itself, and days of labor are wasted in what should be settled once for all, and recorded in a form which is available to all manufacturers.

68. What is needed is a hand-book on the speed with which work can be done, similar to the elementary engineering hand-books. And the writer ventures to predict that such a book will before long be forthcoming. Such a book should describe the best method of making, recording, tabulating, and indexing time observations, since much time and effort are wasted by the adoption of inferior methods.

69. The term " rate-fixing department " has rather a formidable sound. In fact, however, that department should consist in most establishments of one man, who, in many cases, need give only a part of his time to the work.

70. When the manufacturing operations are uniform in character, and repeat themselves day after day — as, for instance, in paper or pulp mills — the whole work of the place can be put upon piece work in a comparatively short time; and when once proper rates are fixed, the rate-fixing department can be dispensed with, at any rate until some new line of manufacture is taken up.

71. The system of differential rates was first applied by the writer to a part of the work in the machine shop of the Midvale Steel Company, in 1884. Its effect in increasing and then maintaining the output of each machine to which it was applied was almost immediate, and so remarkable that it soon came into high favor, with both the men and the management. It was gradually applied to a great part of the work of the establishment, with the result, in combination with the rate-fixing department, of doubling and in many cases trebling the output, and at the same time increasing instead of diminishing the accuracy of the work.

72. In some cases it was applied by the rate-fixing department without an elementary analysis of the time required to do the work; simply offering a higher price per piece providing the maximum output before attained was increased to a given extent. Even this system met with success, although it is by no means correct, since there is no certainty that the reward is in just proportion to the efforts of the workmen.

73. In cases where large and expensive machines are used, such as paper machines, steam hammers, or rolling mills, in which a large output is dependent upon the severe manual labor as well as the skill of the workmen (while the chief cost of production lies in the expense of running the machines rather than in the wages paid), it has been found of great advantage to establish two or three differential rates, offering a higher and higher price per piece or per ton as the maximum possible output is approached.

74. As before stated, not the least of the benefits of elementary rate-fixing are the indirect results.

The careful study of the capabilities of the machines, and the analysis of the speeds at which they must run, before differential rates can be fixed which will insure their maximum output, almost invariably result in first indicating and then correcting the defects in their design, and in the method of running and caring for them.

75. In the case of the Midvale Steel Company, to which I have already referred, the machine shop was equipped with standard tools furnished by the best makers, and the study of these machines, such as lathes, planers, boring mills, etc., which was made in fixing rates, developed the fact that they were none of them designed and speeded so as to cut steel to the best advantage. As a result, this company has demanded alterations from the standard in almost every machine which they have bought during the past eight years. They have themselves been obliged to superintend the design of many special tools which would not have been thought of had it not been for elementary rate-fixing.

76. But what is, perhaps, of more importance still, the rate-fixing department has shown the necessity of carefully systematizing all of the small details in the running of each shop; such as the care of belting, the proper shape for cutting tools, and the dressing, grinding, and issuing same, oiling machines, issuing orders for work, obtaining accurate labor and material returns, and a host of other minor methods and processes. These details, which are usually regarded as of comparatively small importance,

and many of which are left to the individual judgment of the foreman and workmen, are shown by the rate-fixing department to be of paramount importance in obtaining the maximum output, and to require the most careful and systematic study and attention in order to insure uniformity and a fair and equal chance for each workman. Without this preliminary study and systematizing of details, it is impossible to apply successfully the differential rate in most establishments.

77. As before stated, the success of this system of piece work depends fundamentally upon the possibility of materially increasing the output per man and per machine, providing the proper man be found for each job and the proper incentive be offered to him.

78. As an illustration of the difference between what ought to be done by a workman well suited to his job, and what is generally done, I will mention a single class of work, performed in almost every establishment in the country. In shovelling coal from a car over the side on to a pile one man should unload forty tons per day, and keep it up, year in and year out, and thrive under it.

With this knowledge of the possibilities I have never failed to find men who were glad to work at this speed for from four and a half to five cents per ton. The average speed for unloading coal in most places, however, is nearer fifteen than forty tons per day. In securing the above rate of speed it must be clearly understood that the problem is not how to force men to work harder or longer hours than their health will permanently allow; but, rather, first, to select among the laborers which are to be found in every community the men who are physically able to work permanently at that job, and at the speed mentioned, without damage to their health, and who are mentally sufficiently inert to be satisfied with the monotony of the work, and then, to offer them such inducements as will make them happy and contented in doing so.

79. The first case in which a differential rate was applied furnishes a good illustration of what can be accomplished by it.

A standard steel forging, many thousands of which are used each year, had for several years been turned at the rate of from four to five per day under the ordinary system of piece work, 50 cents per piece being the price paid for the work. After analyzing the job and determining the shortest time required to do each of the elementary operations of which it was composed and then summing up the total, the writer became convinced that it was possible to turn ten pieces a day. To finish the forgings at this rate, however, the machinists were obliged to work at their maximum pace from morning to night, and the lathes were run as fast as the tools would allow, and under a heavy feed.

It will be appreciated that this was a big day's work, both for men and machines, when it is understood that it involved removing, with a single 16-inch lathe, having two saddles, an average of more than 800 pounds of steel chips in ten hours. In place of the 50-cent rate that they had been paid before, they were given 35 cents per piece when they turned them at the speed of 10 per day, and when they produced less than 10, they received only 25 cents per piece.

80. It took considerable trouble to induce the men to turn at this high speed, since they did not at first fully appreciate that it was the intention of the firm to allow them to earn permanently at the rate of $3.50 per day. But from the day they first turned 10 pieces to the present time, a period of more than ten years, the men who understood their work have scarcely failed a single day to turn at this rate. Throughout that time, until the beginning of the recent fall in the scale of wages throughout the country, the rate was not cut.

81. During this whole period the competitors of the company never succeeded in averaging over half of this production per lathe, although they knew and even saw what was being done at Midvale. They, however, did not allow their men to earn over from $2 to $2.50 per day, and so never even approached the maximum output.

82. The following table will show the economy of paying high wages under the differential rate in doing the above job: —

COST OF PRODUCTION PER LATHE PER DAY

Ordinary system of piece work		Differential rate system	
Man's wages	$2.50	Man's wages	$3.50
Machine cost	3.37	Machine cost	3.37
Total cost per day	$5.87	Total cost per day	$6.87
5 pieces produced.		10 pieces produced.	
Cost per piece	$1.17	Cost per piece	$0.69

The above result was mostly, though not entirely, due to the differential rate. The superior system of managing all of the small details of the shop counted for considerable.

83. There has never been a strike by men working under differential rates, although these rates have been applied at the Midvale Steel Works for the past ten years; and the steel business has proved during this period the most fruitful field for labor organizations and strikes. And this notwithstanding the Midvale Company has never prevented its men from joining any labor organization. All of the best men in the company saw clearly that the success of a labor organization meant the lowering of their wages, in order that the inferior men might earn more, and, of course, could not be persuaded to join.

84. I attribute a great part of this success in avoiding strikes to the high wages which the best men were able to earn with the differential rates, and to the pleasant feeling fostered by this system; but this is by no means the whole cause. It has for years been the policy of that company to stimulate the personal ambition of every man in their employ, by promoting them either in wages or position whenever they deserve it, and the opportunity came.

A careful record has been kept of each man's good points as well as his shortcomings, and one of the principal duties of each foreman was to make this careful study of his men, so that substantial justice could be done to each. When men, throughout an establishment, are paid varying rates of day work wages, according to their individual worth, some being above and some below the average, it cannot be for the interest of those receiving high pay to join a union with the cheap men.

85. No system of management, however good, should be applied in a wooden way. The proper personal relations should always be maintained between the employers and men; and even the prejudices of the workmen should be considered in dealing with them.

The employer who goes through his works with kid gloves on, and is never known to dirty his hands or clothes, and who either talks to his men in a condescending or patronizing way, or else not at all, has no chance whatever of ascertaining their real thoughts or feelings.

86. Above all is it desirable that men should be talked to on their own level by those who are over them. Each man should be encouraged to discuss any trouble which he may have, either in the works or outside, with those over him. Men would far rather even be blamed by their bosses, especially if the " tearing out " has a touch of human nature and feeling in it, than to be passed by day after day without a word, and with no more notice than if they were part of the machinery.

The opportunity which each man should have of airing his mind freely, and having it out with his employers, is a safety-valve; and if the superintendents are reasonable men, and listen to and treat with respect what their men have to say, there is absolutely no reason for labor unions and strikes.

87. It is not the large charities (however generous they may be) that are needed or appreciated by workmen, such as the founding of libraries and starting workingmen's clubs, so much as small acts of personal kindness and sympathy, which establish a bond of friendly feeling between them and their employers.

88. The moral effect of the writer's system on the men is marked. The feeling that substantial justice is being done them renders them on the whole much more manly, straightforward, and truthful. They work more cheerfully, and are more obliging to one another and their employers. They are not soured, as under the old system, by brooding over the injustice done them; and their spare minutes are not spent to the same extent in criticising their employers.

A noted French engineer and steel manufacturer, who recently spent several weeks in the works of the Midvale Company in introducing a new branch of manufacture, stated before leaving that the one thing which had impressed him as most unusual and remarkable about the place was the fact that not only the foremen, but the workmen, were expected to and did in the main tell the truth in case of any blunder or carelessness, even when they had to suffer from it themselves.

89. From what the writer has said he is afraid that many readers may gain the impression that he regards elementary rate-fixing and the differential rate as a sort of panacea for all human ills.

This is, however, far from the case. While he regards the possibilities of these methods as great, he is of the opinion, on the contrary, that this system of management will be adopted by but few establishments, in the near future, at least; since its really successful application not only involves a thorough organization, but requires the machinery and tools throughout the place to be kept in such good repair that it will be possible for the workmen each day to produce their maximum output. But few manufacturers will care to go to this trouble until they are forced to.

90. It is his opinion that the most successful manufacturers, those who are always ready to adopt the best machinery and methods when they see them, will gradually avail themselves of the benefits of scientific rate-fixing; and that competition will compel the others to follow slowly in the same direction.

91. Even if all of the manufacturers in the country who are competing in the same line of business were to adopt these methods, they could still well afford to pay the high rate of wages demanded by the differential rate, and necessary to induce men to work fast, since it is a well-recognized fact the world over that the highest-priced labor, providing it is proportionately productive, is the cheapest; and the low cost at which they could produce their goods would enable them to sell in foreign markets and still pay high wages.

92. The writer is far from taking the view held by many manufacturers that labor unions are an almost unmitigated detriment to those who join them, as well as to employers and the general public.

The labor unions — particularly the trades unions of England — have rendered a great service not only to their members, but to the world, in shortening the hours of labor and in modifying the hardships and improving the conditions of wage workers.

In the writer's judgment the system of treating with labor unions would seem to occupy a middle position among the various methods of adjusting the relations between employers and men.

When employers herd their men together in classes, pay all of each class the same wages, and offer none of them any inducements to work harder or do better than the average, the only remedy for the men lies in combination; and frequently the only possible answer to encroachments on the part of their employers is a strike.

This state of affairs is far from satisfactory to either employers or men, and the writer believes the system of regulating the wages and conditions of employment of whole classes of men by conference and agreement between the leaders, unions, and manufacturers to be vastly inferior, both in its moral effect on the men and on the material interest of both parties, to the plan of stimulating each workman's ambition by paying him according to his individual worth, and without limiting him to the rate of work or pay of the average of his class.

93. The level of the great mass of the world's labor has been and must continue to be regulated by causes so many and so complex as to be at best but dimly recognized.

The utmost effect of any system, whether of management, social combination, or legislation, can be but to raise a small ripple or wave of prosperity above the surrounding level, and the greatest hope of the writer is that, here and there, a few workmen, with their employers, may be helped, through this system, toward the crest of the wave.

Discussion

Mr. H. L. Gantt. — One cannot read Mr. Taylor's admirable paper on " A Piece Rate System " without realizing that it contains vastly more than the title suggests. It is really a system by which the employer attempts to do justice to the employee, and in return requires the employee to be honest.

His method of fixing rates by elements eliminates, as nearly as possible, all chance of error, and his differential rates go a long way toward harmonizing interests of employer and employee.

It was my good fortune to work for a year as his assistant in this work, and I fully agree with him as to the effect on the men. They improve under it, both in honesty and efficiency, more than I have ever seen them do elsewhere. Realizing that substantial justice was being done, and that to do their duty was to follow their own interest, it soon became a matter of habit with them.

The greatest obstacle in the way of adopting this system is that the man in charge of the rate-fixing department must be a man of more than ordinary ability, and should have had a very wide experience. To err in fixing a rate has a very bad effect upon the men, who should never have reason to think that the element of " guess " occurs in their rate. It is therefore only in a comparatively very large establishment, where a capable man can be employed to give his time to this work, or in a very small one, where the superintendent can give it his personal attention, that the plan is entirely applicable.

His idea of a hand-book on the speed with which work can be done, similar to the elementary engineering hand-books, is one which is bound to interest all progressive engineers, and I hope that he will see that his predictions about such a book do not fail.

In paragraph 15 he states that a clerk in the factory is the particular horror of the old-time manufacturer. Why is this? In many cases the manufacturer is a shrewd and successful man, and if so, why has he not seen the advantage of using a clerk in connection with his foreman?

This takes us back to the advantages of a system. No matter how successful a system may be in one shop, modifications are always required to make it equally successful in any other. No shop should be run to suit the demands of a system, but the system must be modified to suit the demands of the shop. No system is a success unless it makes work go more smoothly and cheaply, and ultimately makes the proper running of a shop independent of any particular man.

The fact that most ready-made systems fail in almost all of these respects makes the shrewd, old-style manager fight shy of them, and regard any approximation to them as a needless expense.

To pay men what they are worth requires that we keep accurate records of their work, and as the foreman is too valuable a man to be used as a clerk, he should have this work done for him, and be free to give his entire time to his men and the work.

Finally, the ideal system must be automatic and self-contained. It must be so simple as to appeal to those working under it, and should impose checks in such a way as to prevent or correct errors without the interference of the superintendent, or of any one not directly connected with doing the work under it, and, above all, it should be free as possible from "red tape."

Mr. F. A. Halsey. — Mr. Taylor's paper points out that in cases where the machine cost exceeds the wages paid, a piece rate which increases with the output may be compatible with reduced cost, as the output advances. Simple as is the idea, it is, I must own, new to me, and it may be admitted at once that in such cases the advancing piece rate is justifiable, *provided the maximum output cannot be obtained without it.* In the average case, however, where the wages paid exceed the machine cost, the condition no longer holds, and the advancing piece rate would involve an increased cost, as an accompaniment of an enlarged output.

It was under the condition of a moderate tool cost that my Premium Plan (see vol. xii, page 755, of the *Transactions*) was devised, and its application, under a high tool cost, was not considered, the fundamental idea being that the workman's earnings *per piece* should decrease (though per day increase) as the output increased. By reference to my paper on the Premium Plan it will be seen that the need of different premium rates to cover different conditions was clearly recognized, and while such a development was not contemplated, it is plain that there is nothing to prevent making the premium rate so high as to give the workman a wage which increases faster than the output, *if the conditions are such as to make that course necessary* to secure the maximum output.

It thus seems to me that, while Mr. Taylor's plan is applicable only to the condition of high tool cost, the Premium Plan not only applies to the condition of low tool cost, for which it was planned, but to the condition of high tool cost as well. There are not many shops in which the maintenance of every tool costs more than the wages of its operator — the tools falling under that class being usually in the small minority. Mr. Taylor's system being economically applicable only to the larger tools, it would seem necessary, if the best results are to be obtained, to apply it only to such large tools, and use some other system for the smaller ones. With the Premium Plan, the same system, as has been shown, applies to all, and its advantage in requiring only one system of time and cost keeping against two, with Mr. Taylor's system, is apparent.

Is it clear, however, that a wage rate which advances faster than the output is necessary in any case? The only system which will endure is the one which pays the least possible per piece of product. The purpose of these systems is not, primarily, to pay high wages, but to produce cheap work, the adjustment sought being one which shall give the workman an increased wage *per day* in return for a decreased cost *per piece* of product. In my experience, a comparatively small premium will call out a workman's best efforts, provided the work is not too laborious, and the workman is *assured against future cuts in the rate*. Why should this not be the case with large and expensive tools as well as small ones, and, if true, why should the wages increase faster than the product, even on large tools?

Mr. Taylor's strictures on the piece work plan have my cordial approval, but what is the fundamental difficulty with piece work? simply that the output under it is always found to be larger than anticipated, and a rate which seemed moderate before trial is found to be excessive after trial. The workman's earnings, increasing *pro rata* with the product, soon get to be excessive, unless he has acquired wisdom and restrains himself. In Mr. Taylor's system, the earnings under an increase of product increase still faster than with piece work, and the consequences of a too high rate would be even more serious than with piece work. Wherein, then, does the superiority of Mr. Taylor's system over piece work lie? *Not in the advancing piece rate, but in the method of fixing rates.* If Mr. Taylor can determine the maximum output of the miscellaneous pieces of work comprised in the everyday operation of the average machine-shop, he has accomplished a great work, and the present paper should be followed at once by another, giving the fullest possible details of his method. It is this universal difficulty of determining the possible output which is at the bottom of the difficulties besetting the piece work plan, and it was its contemplation which led the writer's thoughts to the Premium Plan. With that plan, the attempt to determine the possible output is abandoned. Present output is taken as the basis, and if the premiums offered for an increase are small, as they should usually be, no possible increase of output can carry the workman's earnings beyond reason. It is its extreme flexibility and the absence of danger of expensive errors of judgment which chiefly commend the Premium Plan, and while it is impossible to judge Mr. Taylor's method of fixing rates with the present knowledge of it, I must say that it is hard to conceive anything so simple or safe as the plan offered by me.

Still another point presents itself. When piece work is introduced in place of day work, the rate offered is usually less than the work previously cost. The workmen often object, as few of them know the real capacity of the tools, and the system is only introduced by the exercise of some coercion on the part of the employer. Nevertheless these first rates are eventually found to be too high, and a really large output is only reached after several successive cuts. Now, if the final output is to be determined at once by Mr. Taylor's method, and the rates fixed in accordance, is not still greater opposition on the part of the men to be expected? The maximum output is usually and necessarily a matter of growth. With Mr. Taylor's plan there must intervene a period of low pay.[1] The outcome is uncertain to the workmen. They are full of distrust, and can they be blamed if they rebel? Right here, again, the merits of the Premium Plan are conspicuous. There is no cut at its introduction; on the contrary, present output is taken as the basis, and the workman is offered an increased wage if he will increase the output. The result is satisfaction from the start, and increasing satisfaction as time goes on. Nothing can be simpler, fairer, or plainer, and nothing can meet all the varied conditions more perfectly.

Mr. F. W. Taylor. — In Mr. Halsey's criticism of my piece rate system, he very justly lays great weight on the elementary rate-fixing as the most important part of the system. An accurate knowledge of the quickest time in which each job can be done is the very foundation upon which the differential rate rests, and without this knowledge the whole system must fall to the ground.

Mr. Halsey is in error, however, in his assumption that my system of piece work involves paying a higher price per piece than is paid under the ordinary system. On the contrary, with the differential rate the price will, in nine cases out of ten, be much lower than would be paid per piece either under the ordinary piece work plan or on day work. An illustration of this fact can be seen by referring to paragraphs 79 to 83 of the paper, in which it will be found that a piece of work for which the workmen had received for years, under the ordinary piece work system, 50 cents per piece, was done under my system for 35 cents per piece, while in this case the workmen earned $3.50 per day, when they had formerly made, under the 50-cent rate, only $2.25 per day.

It is quite true that under the differential rate the workmen earn higher wages than under other systems, but it is not that they get a higher price per piece, but because they work much

[1] This was one of the difficulties with the differential piece rate plan which led to the development of the Gantt bonus method. See H. L. Gantt's "Work, Wages, and Profits." — ED.

harder, since they feel that they can let themselves out to the fullest extent, without danger of going against their own interests in the long run. What I said in the paper was that the management could *well afford* to pay a higher price per piece, to insure the maximum possible output, not that it was necessary to do so. Mr. Halsey is right in saying that there is sometimes difficulty in introducing the differential rate, owing to the great and sudden increase in speed which is demanded of the workmen. This is particularly true of the first few cases in which the system is applied in a new establishment — *C'est le premier pas qui coute* — and much tact and skill is sometimes required to get the men to accept and work under the first rate. After the system, however, once has a start in a place, on however small a scale, the workmen are quite as quick to recognize its merits from their standpoint as the management are from theirs.

Mr. Halsey's is by far the best of the ordinary systems of piece work, yet, even under his system, there still remains what to my mind is the very weakest point of all the ordinary systems, and what may be called, almost, the curse of modern industrial management, namely, *that it is for the workman's interest to "soldier" and go as slowly as possible on each new piece of work that comes along*, so as to get as high a price per piece as possible when piece work first starts; and for this reason, even after piece work has been inaugurated, under Mr. Halsey's plan, there is almost necessarily a great lack of justice in the prices fixed for different jobs, since the starting-point from which the first rate is fixed is unequal and unjust. Some of the rates may have resulted from records obtained when a good man was working close to his maximum speed, while others are based on the performance of a medium man, at one-third or one-quarter speed, and from this follows a great inequality and injustice in the reward of even the same man when at work on different jobs.

Other defects of Mr. Halsey's plan, and which are corrected by my system, are: —

First. That it is slow and irregular in its operation in reducing costs, being dependent upon the whims of the men working under it.

Second. That it fails to especially attract first class men and discourage inferior men.

Third. That it does not automatically insure the maximum output of the establishment per man and per machine.

Mr. John A. Penton.[1] — Although I am not a member of the Society, I want to thank you for the privilege of just saying a word. The paper we have just listened to and the presentation made by Mr. Taylor strike me as being perhaps the most remarkable thing of its kind I ever heard in my life. I do not wish to say anything about its merits, or demerits, if it has any. My knowledge of it is altogether too superficial to admit of anything of that sort; but I can sympathize with every word he said, for the reason that fortunately, or perhaps unfortunately, I was for five years at one time occupying the position of president of a very large organization, which would be called a labor organization, prominently identified with the iron business. With us, the treatment of this piece work problem was something which, even now as I think of it, causes me to shudder and to feel a little nervous; and when I think of the problems which might be solved by this paper presented by Mr. Taylor — such a one, for instance, as was solved by the military at Homestead a year or two ago — when I think of all those things, and of the numberless instances which occur almost every year, I feel that, as a workman, I want to congratulate Mr. Taylor and to say that his paper, I think, is a landmark in the field of political economy; and, as all our leading thinkers have devoted their time in the last few years to solving problems of that kind, I feel that the paper he has written is worthy of the greatest consideration at the hands of every employer, and at the hands, also, of the employee. It seems to me that every sentence, almost, might form a text for an article. It certainly enunciates a number of logical ideas, and I feel that I would like to go before the American Society of Mechanical Engineers, and, as a workman, testify to my feelings in the matter.

Mr. W. S. Rogers. — It is strange how we meet old faces once in a while. In 1883, in the State of Ohio, I had charge of men,

[1] Formerly President of the Brotherhood of Machine Moulders.

and that identical plan of a differential piece price came into my head. I was not near as old then as I am now, but I recognize, also, the fact that I am not talking to students now. I am talking to men who know more than I do of how to handle men. A very capable member of this association, who is now dead (Captain Minot), was a particular friend of mine, and I laid this plan before him. He said: " Do you believe in it ? " I said: " I think that is just the thing to fetch my shop right down to where it ought to be." He said: " Try it." He went by my shop to and fro to his, and he would stop occasionally and say: " Rogers, how is the differential working ? " At first I was enthusiastic. At the end of six weeks, he said: " Rogers, what do you think of the differential ? " I said: " Captain, I feel like a thief; it is n't honest. There are times when a man cannot turn out as much work today as he did yesterday, and it is not his fault; the fault lies sometimes in the foundry or elsewhere, and the man is not to blame, but I have got to live up to my rules and cut the price." " Well," he said, " I thought you would feel that way, and I have been feeling that way for you." Then I abolished it. At the Providence meeting, Mr. Halsey read a paper on the Premium Sharing Plan. I have tried it three times since. I have a friend of mine trying it. I am trying that in the shop where I am today, and it is simple and easy, and the men ask for it. You cannot give it to them fast enough, and you do not require a rate-fixer. Now, as to cutting prices and cutting rates, I know an instance that occurred not long ago. A man took charge of a shop, and not ten days after he went there he slapped it on to piece work. Today he is looking for another situation and the firm is cutting the men. You cannot pass to piece work instantly, or anything else, until you thoroughly understand the whole situation; and you have got to throw your hobbies and ideas to the winds and be governed by what you find and the men you find. A short time ago a man applied at our place for work. I make it a point, if possible, to hire every man. He said he was a machinist. He asked what wages he would get. I said: " That depends on you; your rate will not be fixed for one week." I asked where he was from. He replied that he was glad to get away from a place where the differential system was in operation.

Mr. F. W. Taylor. — I must object to Mr. Rogers saying that he tried my system of piece work; for, according to his own statement, he entirely omitted the vital part of my plan, namely, the elementary rate-fixing, without which the differential rate must, in most cases, prove a failure. He, however, says that he only tried differential rates for six weeks, which, in point of fact, is no trial whatever. If he had tried the plan for six years or even six months, and abandoned it, his experience might have some weight, but six weeks counts for nothing. Regarding his statement that his workman was glad to get away from my system, all that I need say is that about a thousand of the most intelligent, most prosperous, and contented workmen in the country are working there under this system, and a majority of these men have been in the employ of the company for more than ten years, without complaint about the system, and without a strike or even the talk of a strike. Can Mr. Rogers say as much regarding the workmen of any other steel works in the country?

Mr. Wm. Kent. — I am very glad that Mr. Rogers has attacked Mr. Taylor's paper. There are very few men who have the courage to do it. I hope there will be others who will rise up and attack it, and I know of no man stronger than Mr. Taylor to repel such attacks. He is just the kind of man to stand a good deal of hammering, but sometimes I think he may come out on top.

In regard to Mr. Halsey's plan, which Mr. Rogers has indorsed, I had the pleasure some years ago of indorsing it also, and I think I was possibly the first one to put it on trial, because Mr. Halsey had told me about it two or three years before he published his paper. So far as I know, the plan has been an entire success. But my opinion is that Mr. Taylor's plan is a little ahead. It is probably a little better, provided it is carried out with proper intelligence, by the right men, with proper sense of generous treatment of their workmen. I regard this whole question, which was started, possibly, by Mr. Towne, in his paper, then continued by Mr. Halsey, and now supplemented by Mr. Taylor's paper, as one of the most important questions, not only before this Society, but before the world to-day — the harmonizing of labor and capital; and this question is not to be settled by the opinion of the old-time mechanics, such as my young friend who has spoken. It is to be settled, after a profound study, by men capable of logical analysis, and by students of political economy, and I do not expect that we are going to introduce any of these systems, in any great degree, by the men who are now over fifty years of age, who have all their old-time prejudices; but I think it will be from such men as the one who presented those opening remarks, such as Mr. Gantt, a young man, a technical graduate, who has given some attention not only to workshop matters, but to political economy, and that such men will be the ones who will introduce this system in the long run. I hope to see this subject of workshop economics taught as an inductive science from actual statistics — statistics of tool cutting, of wages, of rates, in the modern method of studying political economy; that this science must be taught in our technical schools, and that our graduates will graduate, not with the knowledge of how to apply this system, but with minds trained to begin studying the system in practice, and gradually the proper systems for our shops will be evolved. I heartily congratulate Mr. Taylor on the paper he has presented, and hope he will continue his studies for a great many years to come in this direction.

Mr. D. L. Barnes. — I would like to ask Mr. Taylor a question about a matter upon which he has not entered in his paper. How does he deal with the apprentice system? A good apprentice will often do as much work as a journeyman. Now, is he to get the same price? The temptation for the manufacturer is to use as many apprentices as possible. How are disputes about apprentices with labor organizations to be settled? That, to my mind, is the most important problem with which a manufacturer has to deal, when the work is such that an apprentice can do it.

The plan proposed by Mr. Taylor is applicable in a shop where the profit is great and where there is an unlimited amount of orders to work on. But suppose the contract price is fixed, and the orders are not very frequent, and the profits small; can a man afford to pay more for extra quality work than for what will pass as good work? It seems to me that the manufacturer can afford, under those conditions, to pay only one price, and that is to get work good enough to pass inspection, and how the differential rate system can be applied under those circumstances I do not see.

Mr. Taylor. — The answer to that is this: With regard to apprentices, in the first place, the Midvale Steel Company takes no regular apprentices, in the old-fashioned meaning of the term, but they do take a great many boys, young men, and even older laborers, and teach them trades, and when I was there I treated my apprentices or learners just as I would the other men. I let them earn all that they could earn, and I was delighted to have them do it. I do not care who turns out my work. So much work is worth so much money, whether done by an apprentice or by a man just tottering to the grave. With all due respect to Mr. Barnes, the apprentices or learners are not able to do, in my experience, anything like as much work as the first-class trained workmen are able to do, and under the differential rate system they must be content with the lower price per piece. They, however, always have the higher price per piece before them as a goal, to spur them on to become fast and accurate workmen, and the system has certainly worked admirably in this respect, since I should say that fully two-thirds of the skilled workmen of the place have been taught their trades right there in the steel works.

As to the second matter referred to by Mr. Barnes, namely, the applicability of the differential rate to a shop which did not have sufficient work to completely occupy all of its tools; if the differential rate system involved paying a higher price per piece than is paid under other systems — that is, if you had to pay with the differential rate actually a higher price for a piece than your competitors pay — then Mr. Barnes is perfectly right in saying that in a shop which runs slack of work this could not be done. As I have already explained in answering Mr. Halsey, however, in most cases where the differential rate is applied your actual piece work rate is lower than your competitor's price is, so that you have the advantage not only of a larger productivity per tool, but also a lower price per piece.

Mr. Gustavus C. Henning. — I would like to add a few words in commendation of Mr. Taylor's paper, not because I have been an employer of labor, but simply because I have suffered from being in intimate connection with unsatisfied laborers. I found that, in shops where the old-fashioned piece rate was in vogue, every time a man did a good piece of work his wages were cut down. They would induce a man to turn out the work on the plea that it had to go out in a hurry, and just as soon as his amount of work increased his rate was cut down, so that he was always kept to earn about the same amount of money per day. I remember one case where this had a very important effect on the character of the work. It was driving rivets. The men were driving originally about 2,500 steel rivets, with hydraulic riveters, by contract, but they earned so much money at the rate they were getting that before the next lot of similar work was contracted for a lower rate was offered, and the men had to drive 3,500 instead of 2,500. The first trouble that arose was that 90 per cent of the rivets were not absolutely tight. Then the shop began to question the propriety of the inspector marking all the loose rivets, because most of them could only be shown to be loose by tapping them on both sides of the head, but if tapped on one side only they would rarely show a defect. Then the men were made to cut out this work at their own expense and put in new rivets, the shop paying for the new rivets, but the labor was found by the riveting gang, and they lost money. Then the power for driving the rivets was increased, improving the work very much. The men actually succeeded in running up their capacity to about 4,500 rivets per 10 hours, but there were so many loose ones in the work that the men, of themselves, discarded the use of steel rivets, although it was prescribed by the specifications, and used iron rivets, because they could be driven tighter. Then, when the objection was made that the contract called for steel rivets, heaven and earth were raised to prevent the reintroduction of steel rivets, and the work was shipped one hundred and twenty-six miles, with these wrought-iron rivets in place, and it was only after the severest fight that they were compelled to cut out about 3,000 iron rivets in the field and replace them by steel, simply to make the contractors understand that they would have to carry out their agreement. That was all caused by the piece rate system. If such a system as this had been in use, such a thing could never have occurred. Those men were trying to do their best, but by doing their best they were compelled to work harder and were getting less and less pay; the work was inferior to what it was when the men were getting less pay and turning out less. I think, if such a system as Mr. Taylor here describes can be carried out on any work in hand, and arranged to suit the particular shop in which it is to be introduced, it would certainly improve the work, increase the capacity, and make the general relation between employer and employee a far more satisfactory one than it is in many of our works at the present day.

Mr. C. E. Bement. — I would like to ask Mr. Taylor a question or two. Do I understand that when the maximum day's work is fixed, it is never changed?

Mr. Taylor. — When, by the elementary rate-fixing, you have found out what a maximum day's work is, for instance, on a lathe or a planer, on a certain class of work, that rate is never changed until some new element enters the problem; that is, until you have a distinctly new method of doing the work. If you invent a new tool which will turn out more work, or if the machine heretofore used is materially improved or better speeded, etc., then the rate is altered; but while the conditions remain the same as originally, and after a careful and thorough analysis has been made of the quickest time in which the job can be done, that rate is never cut; that rate remains permanent until a material change takes place in the rate of wages paid throughout the country — such a change, for example, as occurred very generally in the rate of wages paid in 1893. At this time, the rate of wages paid under differential rates was cut, and the men did not complain of the cut. They saw the justice of it.

Mr. Bement. — Suppose, in ordinary piece work, the same pains was taken and the piece work price was fixed on that basis, would n't that be as just as your system? You fix a day's work which you calculate is the greatest that the machine or man can turn out. Now, suppose in an ordinary piece work shop, such as I am running, we fix a piece work price based on a maximum day's work, why is not that as just a price, provided the same pains is taken to fix it?

Mr. Taylor. — If you can once persuade your men that you are really going to allow them to earn more than the usual standard of wages no differential is essential; that is to say, it is not then nearly as necessary as it usually is. I think I said distinctly in the paper that, after your men are thoroughly in accord with the management and you are all pulling together, it is possible to drop the differential rate without a great sacrifice of the amount of your product, but even then you will make a sacrifice of possibly 10, 15, or 20 per cent of your product, because the incentive of earning his differential is lacking to make each man work to his maximum. The case is very much like running a race — if there is no goal to reach, if each man can go at any rate of speed to suit himself, they will not go as fast as they will if they have got to get to the tape at a certain time, or else forfeit their premium. That is the incentive of the differential rate. What I did not speak of and what is of equal importance is, that it spurs the firm to keep their shop in the best of order. Everything must be kept up in the finest state of repair, or the men cannot earn their differential rate, and I think, if possible, that this indirect result of the system is a greater benefit to the firm than the rate is itself.

Mr. J. L. Gobeille. — This paper is especially interesting, since our moral responsibility toward those in our employ is so prominent a feature of this discussion. In a certain concern, twenty men were displaced by that number of women, the output of both being practically the same. Now, the average pay of these women was much less, perhaps one-half what the men had earned.

While we are discussing ethics and morals, the question comes to me whether it is right to put those women in at the highest rate they had previously earned, and thus save an equal sum for the department, or whether they should have been paid, as Mr. Taylor paid his apprentices, equal pay for equal work. Apprenticeship, by the way, is a back number and a lost art, except in shops in small country towns, and they do not pay the same rate as men get per unit of work.

Seriously, I believe the "woman question" will be prominently before the Society in a few years. In a little while women will be running all the lighter tools in machine-shops and factories. This is certainly coming. I am doing it and others must come to it.

Believing that our first duty is to the workman, and profit on the investment a secondary consideration, what discrimination, if any, shall we make between men and women, without, perhaps, in every instance taking the high moral ground that Mr. Rogers esteems so important in running a factory?

Mr. J. F. Holloway. — Feeling that I may possibly claim a place in that class known as old-time mechanics, I would like to say a few words on the matter under discussion. It certainly does commend itself to all thoughtful and well-meaning persons, that there should be some method provided by which workmen could obtain a better rate for what they do, and, at the same time, that proprietors should make more money out of it. Whenever that can be accomplished, it certainly will be a long step in advance. It seems to me that, in these latter days, so many combinations and so many differences have come up that it is exceedingly difficult to see how this may be brought about. The changed conditions in manufacturing, especially in the line of manufacturing with which most of us are connected, that of machinery, are so different from what they were years ago that they have brought in new complications. As Mr. Gobeille has well said, he doesn't know where the apprentices are to-day. I myself hardly know where you will find apprentices. When Mr. Rogers and I were boys, the apprentices were in small shops. The machine shops of this country were individual shops; they were owned by the man who operated them, or by a small partnership, and the apprentice had the privilege, the inestimable privilege, of living in the family, of getting up in the early morning and making the fire, milking the cow, and taking care of the horse, before he went to work in the shop. There was a certain community of feeling, in those days, between the boys in the shop and the master, which I think passed away when machine-shop owners became corporations, when they were managed by a board of directors who never saw the workmen, who knew nothing of them, individually, and, as I fear, cared less.

It is unfortunate in many ways that there should have been that sort of a diversion of interests, that sort of almost antagonism which has grown up in these latter years between workmen and their employers, and often for the reason that they do not know who their employers are. They know the superintendent of the works, and they know their foreman, and they have a slight acquaintance with the paymaster, through the medium of their check number, but over and beyond that they do not know who they work for. They never come in contact with the owners, and that sort of human contact which is so essential to good feeling, as Mr. Taylor has well observed, is not now prominent. The directors look only at the balance sheet. If the affairs of the company have been well managed, or the state of the market has been such as to enable them to show good balance sheets, then there is nothing said; but if unfortunate contracts have been made, or if the market prices have gone down and the balance is on the wrong side of the ledger, the directors, meeting in solemn conclave, say, Well, we have got to cut the workmen, and they do so; and in doing that there has grown up, as I say, a sort of antagonism between workmen and employers which is exceedingly unfortunate for both. If any way can be devised by which this can be remedied, it will be certainly an advantage to each. So far as the intent of the paper is concerned, and so far as the many good things in it are concerned, I heartily commend it, and I am very glad, indeed, to have listened to it. I am very glad, indeed, to know that there are gentlemen in the profession of engineering who are thinking and studying about the social side of these questions, and I am in hopes that something may come out of it which may be of mutual benefit. There are other elements which have come into existence in latter years which have been, I think, equally harmful. Among them are organizations, ostensibly for the benefit of the workman and possibly in some ways truly so. In many instances they have assumed to do the workman's thinking. They have assumed to take care of the workman, as they say, but unfortunately, in many cases, the men who have thus assumed to take care of the workmen are not the men who should have been put in the place of leaders, and it is, unfortunately, often for this reason that strikes arise, that divisions take place. There has grown up a feeling that one man shall have the same pay as another man, irrespective of his skill, experience, or industry. I think that is unfortunate, because it detracts from the energy and from the industry and from the ambition of a good man. These associations, which I am quite willing to believe were intentionally well-meant, and designed for the welfare of the workmen, compel certain things which I am certain do not in the end conduce to their advantage, because it brings all men to one lower level. No matter how good workmen they may be, no matter how industrious they may be, no matter how ambitious they may be to get a home for themselves and their family, they are tied down to one common grade and they are controlled often by one person, so that the individual liberty of the workman today is wanting.

As to the matter of apprentices and as to the matter of pay that they may get, I would say that the work of today is done largely by special machinery. I can hardly agree with my friend Mr. Rogers in his suggestion, elsewhere made at this meeting, that we should do away with all engine lathes, and throw them into the scrap heap; but it is true that the special machines of today largely supplement the industry and the intelligence of the workman. A bright young fellow, without any previous mechanical training, can go into almost any establishment and go on almost any machine, and with industry and application he can in a very short time do just as much as a skilled workman on that machine. In fact, the term skilled workman is now a very indefinite term. He may be a skilled workman on a slotting machine, or a shaper, or milling machine, but the true skilled workman, whom you could send anywhere to do anything, and who could accomplish it with few or no tools, is sadly wanting. So I can hardly see how you can manage the apprentice part of any system so long as there are no longer any apprentices to apply it to.

Mr. F. W. Taylor.[1] — I am much surprised and disappointed that the elementary rate-fixing has not received more attention during the discussion. No better evidence could have been produced, however, of the crude and elementary state in which the art now stands, of determining the time to do work and of fixing rates, than that only one member of the engineering Society which is in the closest touch with the manufacturers of the country should have most briefly referred to the matter, while thirteen engineers have discussed at length the less important matter of what kind of piece work to use.

I am, nevertheless, mostly firmly convinced that the question of scientific rate-fixing must occupy more and more of the attention of manufacturers in the future. Competition will force the subject upon them.

I think that this will prove a most fruitful field for investigation for young engineers in the future.

[1] Author's closure under the rules.

WAGES AND WAGE SYSTEMS AS INCENTIVES

By C. BERTRAND THOMPSON

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"How do you pay your men?" the manager of a thriving New England plant employing about a thousand hands was asked.

"I started thirty years ago with a straight day rate, and an occasional piece rate in some departments. Now I am using about every system there is: day rates, piece rates, premiums, Gantt bonuses, Emerson bonuses, some Taylor differential piece rates, and salaries and commissions in the administrative and selling departments."

"Why do you use so many methods?"

"I have had to in order to meet the changing conditions of the labor market, not only with day laborers, skilled workmen and machinists, but with clerks, executives, and salesmen. Men are entitled to a wage for giving me their time to dispose of. I have to pay my watchmen just to be present, though they may have nothing actually to do once in ten years. But what I want more than anything else is that my men shall employ their time productively, turning out goods, superintending manufacture more effectively or selling my output. This takes more than their time. It takes their energy, their thought, their interest and their enthusiasm. I found that these desirable things could not be had for a mere day wage. The problem of securing them was one of market conditions and the psychology of the workers.

"My grandfather ran a mill where the women who tended the machines would leave them whenever they liked and go out to look after their children playing in the factory yard. These occasional absences didn't make much difference, since they were working twelve hours a day. Then the shortening of hours began, until now I am running only forty-eight hours a week. In the old days competition was not very keen, and all industry operated at about the same level of inefficiency. Today we have to work for all we get. And above all we must have efficiency in the factory and in the selling field.

" When the pressure began to be felt, we could get our work up by the simple though disagreeable process of driving. But that does not serve any longer. Workmen, especially if they are skilled, and competent executives and salesmen, do not have to stand it. We have had to depart widely from the old day wage and piece rates, therefore, in order to provide some incentive for the men to give voluntarily the volume of production and the personal efficiency which employers must have."

He went on to tell me about some of his experiences. There was a girl in his plant working on hand-folding. Her day wage amounted to $6 a week. At one time this work had been done on a piece rate basis. Figured by the old rate, the girl was actually earning just $1.05 a week, as against the $6 she was getting. This discrepancy was called to her attention daily, but without effect; and after five weeks she was discharged. Her sister, employed in the same plant, pleaded for her reinstatement, on the ground that the girl had not understood that she was expected to work for that price; she supposed she was paid just for her time. A bonus plan carefully worked out was applied to this group of workers, and thereafter there was no trouble.

This illustrates the idea that some men have: that they are paid a day wage just for being in the shop or the office, and that if the employer wants productiveness and " results " besides, he must expect to pay extra for them. It is like the carpenter who applied for a job in one of the Thames shipyards. When asked what wages he expected he said: " Three shillings if I take the hammer here," up near the head; " four shillings if I take it here," half way down the handle; " Five shillings if I take it here," at the point where he could work most efficiently with it.

What the employer wants, in most cases, is of course not the mere time and presence of the employee, but his productiveness. If the manager could abolish day rates and pay only by the piece for what the man produced or sold and nothing more, he would do it. Or, if he held to the day wage, he would like to pay only for the time actually spent on production or selling. He would have time tickets for every moment of the day, and would pay on those only which were productively used. If a man waited about between jobs it would be on the man's own time. This is, of course, impracticable. Many delays between jobs are inevitable, and others the management has not taken the trouble to eliminate. In the majority of cases the employee who waits is not the one who is responsible for the delay, and his living cannot be made dependent on other people's failures.

"The question I have to solve," said the manager, "is how to get all the time of my employees occupied productively, continuously and efficiently."

The old answer to this question, and one still tried in some places, is plain driving. A young man was sent to a quarry in Vermont where the output for some months had been unsatisfactory. He was told to put in force the modern efficiency methods he had just read about in a book, but especially to get a larger output. When he got there he found that the men were loafing outrageously. He forgot all about his book and started in at once to get behind them and drive them to efficiency. His program worked for about six weeks, then there was a strike.

The expedient of cutting piece rates to such a point that the worker will have to go at a furious gait to earn a living is a familiar one. A big company in Pennsylvania worked this plan regularly for several years, until in the end its men struck. Others are still doing it, and have "gotten away with it" thus far; but competent workmen shun such concerns, and those who stay are merely waiting for a good chance to break out.

Human nature reacts on this practice in much the same way in all grades of employment.

Some managers have cut an agent's commissions in the effort to make him hustle. A Boston firm in a growing specialty business put men on the road who were soon earning commissions amounting to an average of twenty dollars a day. Orders were coming in fast; but the firm decided that this rate of pay was too high and should be reduced. It took long and hard-fought argument to convince them of the folly of this course. Their agents, good men, bringing in large contracts, would undoubtedly have quit the firm had the proposed reduction in commissions been made.

The contract system is a modification of the day wage, intended to accomplish some degree of speeding up without placing the responsibility for driving where it belongs — on the employer. The manufacturer hires the contractor at a fixed sum, and the contractor sets a rate of pay and a speed of work which will enable him to get as much as possible out of the contract. He has every incentive to drive the laborer up to and beyond the limits of safety. This is the essence of the sweating system. Its excesses can be restrained only by law, or by the employer who steps in between the contractor and his force; and if he does this he may as well eliminate the contractor altogether. This is just what has happened at a great locomotive works which once had a full-fledged contract system, but now retains only the name. Its contractors have ceased to be anything but sub-foremen.

This policy is rapidly waning in popularity, all the more rapidly as labor becomes more effectively organized. The elimination of ruthless driving is one of the best things to the credit of the labor unions. Where the work is mental rather than physical, as in the case of salesmen, executives and clerks, driving has never resulted in permanent gains. You can prod an agent into the presence of the prospects every day, but you can't make him sell.

Intensified competition between managers, and a growing self-consciousness and independence in the workmen, have made it imperative that some incentive to increased production be provided, which will accomplish what driving was intended to do but failed in. To provide this incentive is one of the tasks of management today.

There are four principal levers by which you can move a man to action: fear, pride, ambition, loyalty. Not all men can be moved by all of them, nor do they all have the same value as incentives to efficiency. Fear is one of the strongest of the emotions but is brutalizing in its effect, is therefore least effective, and is becoming daily more difficult to apply, except in unusual conditions. Mere pride or emulation, when aroused, works beautifully for a time, but soon wears out. People soon get tired of either winning or losing, especially if the game is costing them considerable effort, and the only reward is "honorable mention." But when combined in some way with a more substantial gain, pride may be made a most powerful incentive. Ambition, when effectively appealed to, is stronger still; but the longest lever of them all is loyalty. People will do most and best when they are deeply and fundamentally loyal. Loyalty, like love, is a more or less unreasoning force, which has but one aim: to do one's best for mistress or manager.

These levers can be swung on two fulcrums: the market rate of wages, or a rate above the market. In the rest of this article we shall see how wages "at the market" may be modified to rouse the motives of efficiency; in the next, how wages "at the market plus" can be applied to the same end.

The market rate of wages obviously makes no appeal to ambition. The forces determining it are apparently beyond the control of the individual laborer, and ambition appeals to the individual.

In a few rare cases emulation may be brought into play. A scheme has been worked out in connection with construction work whereby the contractors succeed in getting gangs and individuals competing with each other. "Athletic contests" are arranged between gangs building piers. Both start at exactly the same moment on the same kind of pier; they have the same service, the same bricks and mortar. The winners are decorated with buttons. This works well for a short time; and by the time the enthusiasm has died down the job is ended and the contractors are elsewhere starting the same "contests" with a new set of workmen. So it is with sales contests. Unless the contest is followed by substantial benefits for the contestants, or dissolution of this organization, about one in a generation is sufficient.

The goad of fear will make a man work better than no incentive at all. With wages at the market it can be brought into play only in bad times, when other jobs are scarce. When all employers are "full up" the men with the jobs have got to do what the boss tells them. Of course this is very far from efficiency, but it is perhaps better than blank indifference and positive soldiering. All employers have noticed a seasonal variation in the attitude of their men. When there is plenty of work discipline becomes difficult. When work is scarce every one is remarkably willing to please.

Fortunately the incentive of fear has practically ceased to operate, especially with skilled men and in highly organized trades. The competent salesman or artisan can always get another job, and the unions will see that the ordinary man is not allowed to starve for asserting his manhood. And it is well for the future of efficiency in industry that the employer is forced to appeal to some more humane and elevating motive.

The thing to do is to arouse the enthusiastic loyalty of the employees. Sometimes that is done by the sheer force of the personality of the employer. Some managers are "magnetic." They draw people about them by their personal charm. They seem to emanate fairness and democracy. Every member of the force feels that the manager knows him personally and likes him. This is a gift of the gods.

The president of a great company with five plants in different parts of the country tells me that one of the chief reasons for his success in dealing with his employees — and his men all swear by him — is the fact that his door is always open to any one who wants to see him for any purpose. He will talk over anything with his employees, from the granting of a holiday to the naming of the latest baby. Unfortunately this policy is limited in its application both by the personal deficiencies of many employers who have not this divine gift, and by the defects of organization which do not permit the ordinary manager to spend very much of his time on these "confabs."

A policy which has attracted increasing attention in recent years is the so-called "welfare" work, which at its best is the policy of doing things for the employees which they could not do for themselves, and not from charitable motives but with the object in view of making their lives more attractive and healthful and the workmen more efficient.

This is a somewhat risky policy, beset with dangers and temptations. It has had some conspicuous failures; but it has also been made to succeed conspicuously. It appears to work best when it comes in response to the real needs of the employees, like the reading rooms at the desert stations on the Santa Fe; when it is done unostentatiously and not for the mere purpose of advertising; and when it is done inexpensively and economically, so that there can be no suspicion that large sums are being spent on frills which had better be paid out as wages.

Provision can be made for outdoor athletic sports on vacant fields at very small expense. This is always appreciated and effective; whereas a large and gorgeous clubhouse may be entirely neglected and the management that built it despised. One company turned over a large room in its plant for the use of a girls' club; the girls accepted it, but were not really happy until they were allowed to pay for the heat and light. Not until then did they begin to talk about " their " clubroom, and to bless the management. Lavish expenditures for "welfare" challenge criticism, and invariably arouse all that suspicion which centuries of oppression have ground into the wage-earner. Only the more intelligent and better-paid employees can really appreciate the value of such collective expenditures for them.

Here again the personal factor enters largely. When " welfare " work is in the hands of an unpopular man it almost invariably fails. In one very large establishment the development of the " welfare institutions " was entrusted to such a department head. He got as far as the organization of a mutual benefit society. Some time ago it was announced that the manager was going abroad, and it was hinted around that the proper thing would be to give him a farewell dinner. Every one was delighted to go to the dinner — they were so glad it was his farewell. But when he came back a few months later the point of view was changed. Unwittingly, with the remembrance of his farewell dinner urging him on, the unpopular manager thought it would be a pleasant thing for the mutual benefit society to have a picnic, partly at the company's expense. The picnic was arranged, and something like $400 spent on it. Out of ten thousand employees about forty went. Today that concern has doubts about the value of " welfare " work. And yet it needn't have, if it were only wise enough to see where its mistake lay.

These supplements to " wages at the market " are helpful, when the situation is such that they can be used; but it is the opinion of many managers that after all they are supplements only, and that the body of the problem is the setting of a fair market rate. If your employees are convinced that their rates are fairly set, there will be no great active enthusiasm, to be sure, but you will have a basis for a powerful appeal in time of stress. This raises the question, " What are fair wages ? "

Merely to answer, " the prevailing rate," is not to answer at all. For our question is, in other terms: " Can we show that the prevailing rate is fair ? "

The wages which might possibly be paid lie somewhere between the lower limit of subsistence for the employee and the lower limit of subsistence for the employer. If the employee does not get at least this minimum he will quit or die, or both. The employer, on the other hand, has got to get enough to pay his employees, to pay for materials and equipment, and to support himself. In addition, he has got to clear enough to make it worth while for him to stay in business and take the risk and the trouble that both involve, rather than shun the risk and trouble by taking employment with somebody else.

The value of the product has nothing to do with these minimum limits; nor have these limits much to do with the value. Society, the whole body of consumers, sets a value on the product quite independently of the wants or needs of either employer or employee. In the bicycle business, for instance, when the community at large decided that it no longer cared much for bicycles, no amount of need on the part of manufacturers could induce society to pay what would have been necessary to keep them in business. Neither did the fact that a large number of people were thrown out of work when the desire for bicycles disappeared have any effect on society.

Society sets the price or value of work done for it in accordance with methods of its own, entirely distinct from the needs of either employer or employee. Their payment has got to come out of that value; somehow or other it has got to be divided between employer and employee; and the whole question of fairness centers around the mode of this division.

The popular theory among many economists today is that the division is made in proportion to the relative contributions of each group and even of each individual engaged in the process of production and marketing. This would be comforting if it were true; but unfortunately it does not seem to fit the facts. What part of the value of an article is contributed by employers and employees respectively, and then again by different groups, such as manufacturers, salesmen, transportation companies, and retail clerks, and finally by each individual in those groups, it is absolutely impossible to say.

When you find, for instance, that 30.6 per cent of those in the patent medicine business are clerks, how are you going to determine what each of these clerks contributed as compared with the people who ground the materials, the mixers, the machinists, the bottlers, the labelers, the packers, the advertising men, and the rest? How is it possible to apportion, out of the dollar (or the 59 cents at the cut-rate store) received for the bottle, the contribution of each of those people, or even of each group?

The same analysis must be applied to every business. There are certain stages in the progress of some kinds of work where you can reckon the actual physical contribution of an individual workman with some degree of accuracy; but in no industry is it possible to determine what proportion of the value of the finished and marketed product was contributed by any one workman or group of men.

If the theory won't help us, perhaps the facts will. Statistics show with some clearness that the wages of unskilled laborers vary with the cost of living. When the cost of subsistence goes up wages must go up too. Wages of skilled labor are those of unskilled plus a certain addition, determined by several factors, as will be seen in a moment. Statistics again show that the wages and salaries of skilled workmen vary fairly closely with the standard of living; but it is not clear in this case which is cause and which is effect: that is, whether high wages make a high standard of living, or vice versa. The probabilities are that it is both; when wages go up, the standard of living rises; this makes a new minimum of subsistence for the skilled man; this makes it possible for him to resist strongly any tendency to reduce wages below his new minimum, and exerts a continual pressure to raise them above this point.

The trained man is also helped by the possibility of getting more in some other business or employment. The employer has no measure of productivity in many cases by which to set the salary; he has to go by what his man can get elsewhere; he has to pay the man's "opportunity cost," as the economists call it. Your clerk getting $1,000 thinks he can earn $1,500 writing ads; so he threatens to go into the advertising business. If you want to keep him you have got to come up to his new expectation, especially if he is really a competent man, and the chances of success are in his favor. Skilled men are comparatively scarce; the demand for them is great, and their opportunity cost is therefore higher. They get higher wages than the unskilled, not because of any social obligation felt by their employers, but because they are able to command them.

Another important factor in determining the division of the value of the product between the employer and the employee is organization. Skilled labor gets a better wage partly because it is better organized. Unskilled labor is organizing, and is finding its conditions improved at once. Organization counts tremendously in deciding what share of the zone between the limits of subsistence of the employer and of the employee is going to labor. The employer holds the funds, he is the one who makes the payments, and it is he who determines whether he will employ at all or not. He therefore has an immense advantage in bargaining which can be met only by organization.

That this advantage can be counterbalanced even by comparatively unskilled labor and on short notice has been shown by the success of the Lawrence strike and the recent coal and railroad strikes abroad, where the men have shown that they are the masters of the situation.

In the popular mind, to which appeal must finally be made in the questions arising between capital and labor, a fair wage is that which permits the employees to maintain the standard of living to which they are accustomed, and which therefore rises with increase in the cost of living. It will vary also with the margin between cost of materials, plus overhead, and the selling price; that is, when this margin is large and business is prosperous, labor is expected to get a larger share; when the margin falls, labor must expect a decrease of wages. This is an automatic sliding scale which public opinion will always support.

I asked the president of a large company, who is especially interested in the handling of his labor, how he determined the wages when he started a new department. He could not go by the market rate in that vicinity, for there was none. He said he began by setting the wage in accord with the neighborhood cost of living and the standard of the men he would take on for his new work; later he modified the wages as necessity required or opportunity allowed. He paid higher when he could, less when he had to.

Fairness in setting a rate " at the market " helps when trouble comes and it is necessary to make an appeal to the sense of justice of employees and public. It is thus a form of insurance, a negative benefit. It does not arouse any enthusiasm, for people expect a man to be fair, and are merely not disappointed when he is. To awaken the enthusiastic support and coöperation without which the efficiency demanded by modern conditions cannot be had, something more than this must be done.

It is pretty clear to most managers that the policy of paying wages and salaries " at the market," while it may do for the ordinary run of ordinary business, will not do at all for those kinds of business which demand the highest grades of productive, administrative and selling ability. Fair wages, sensible " welfare work," and a winning personality in the management will get and keep a fair organization of hardworking, conscientious " pluggers "; but it does not and cannot secure that brand of enthusiasm which makes the prize-winning business, as distinguished from the common or garden variety. The prize-winning organization must be built up by careful nursing of all the best talent available. You get this talent, and then keep it after you have trained it, only by offering, in some way, to pay more for it than the other fellow pays; in other words, you must set your wages and salaries somehow " at the market plus."

A rate a little higher than your competitors are paying appeals to every incentive that makes for efficiency. One of the floor foremen in a certain concern was a competent fellow when he wanted to be. He could maintain discipline, get the work out and keep up the quality. But he was a suspicious and grouchy individual, and every once in a while would decide that the firm was trying in some way to " do " him. Of course, while in these moods his chief aim in life was to retaliate, in some quiet and unobtrusive way, which would be none the less effective. He was finally brought into line by paying him 10 per cent more than the prevailing rate. Thereafter, though he was still suspicuous and grouchy, whenever he showed any tendency to " lie down on the job," the firm would bring out a powerful argument, to wit, the loss of that 10 per cent bonus he would suffer if he had to get a job elsewhere. Fear was the only emotion which could reach this man; and as he was highly skilled, and could get another job at any time, the only way this spring could be tapped was by paying him above the market.

The moment you pay a man or woman a higher wage or salary than other people in the same neighborhood and line of work are getting, you have touched that motive of pride and emulation which is such a powerful incentive with the higher grade of employees. In one factory where there is a bonus system the employees have organized a " Bonus Club," to which none are eligible except those capable of earning the usual bonus of 30 per cent. The privilege of belonging to that club, the Phi Beta Kappa of the mill, is as eagerly sought after as the increase in pay. It is like publishing the pictures of the sales agents who make the biggest selling records. These men become known and quoted as authorities. All the best stories are attributed to them. They may even become the center of a sort of hero-worship, with its set of legends and its group of disciples. And this kind of incense, combined with substantial increases in salaries and commissions, works wonders. But the picture alone will not.

If the market rate is somewhere near the standard of living, those who get something over the market are in position to maintain that standard and a little over, which they can put in the savings bank or into a building and loan association. This policy gets and holds the men of ambition and initiative. One publishing concern, which pays a bonus on sales, is considering the feasibility of paying that bonus in the form of a savings bank account, partly to see who among its agents are the men who appreciate its value. These are the men it will keep and promote. As the account grows their ambition grows with it; their self-respect also increases and they become incapable of falling below the best that they can do.

In a factory which was introducing the bonus system it was the policy to offer the bonus to the men for their voluntary acceptance. It almost invariably happened that the first men in each department to accept were those with families who were planning to " get ahead " in some way, usually to buy a little lot and build on it. The sight of these men earning their bonuses and demonstrating the possibility of getting out of the rut of day wages soon stimulated the ambition of the others, and under the impetus of this goad they pleaded for the opportunity to earn the bonus — even those who originally had opposed its introduction. The net result in one department, after certain changes had been made in the construction of the machines, was to increase the output 105 per cent and the wages of the men 50 per cent.

Loyalty is an important factor in any industry or business, and especially in those where it is difficult to measure the output, and where the output depends largely on the way the man feels. An executive or salesman does his best when he feels " right." The same is true of the clerical force. Where the work is largely mental — and all work is at least partly mental — the state of mind of the employee is the most important condition.

A man whose pride and ambition are aroused and satisfied by the firm he is working for is pretty apt to have a strong feeling of loyalty for it. This sentiment can be fanned into a roaring flame by the policy of what might be called "ultrafairness"; that is, not only paying for what the man does directly, but for what he does indirectly as well. An insurance agent, for example, lands his risk; after that the company takes care of it, follows it up, does all the collecting and the accounting; but when the renewal comes, the company pays the agent just the same.

For the agent this is like finding money, although, of course, he did have something to do with it originally. This near-gift ties him to his company. A similar policy is pursued by a specialty manufacturing company which is famous for the loyalty of its sales force. The country is divided into districts, with an agent in each. Any sale made in a district, no matter who made it, pays a commission to the agent in whose district it is. The sale may be made to a visitor at the works of the company, or by another agent who met the customer in another part of the world; it makes no difference.

This not only gets the loyalty of every agent, but in addition it tends to eliminate jealousies, and to make the knowledge of one of the men the possession of all of them. A well-known magazine, which publishes books to be sold only by advertising in its own columns, does something like this. It pays the magazine agents and canvassers a bonus on the books sold; they have nothing to do with selling books, except that the sale of the books is dependent on the circulation of the magazine. This indirect relationship protects the deal from the charge of "charity"; but at the same time it is so indirect that it looks like a mark of special consideration on the part of the house.

The secret in all these plans is that they give the employee the feeling of the bondholder, the "plute," who apparently gets his money with no effort at all, except to open his pocket and let it drop in. This feeling is so rare, and so delicious, that most men and women will do anything for the employer who can give them the experience. It is like riding in the boss's auto. You can feel, for the moment, all the commiseration which you imagine he feels for the ordinary pedestrian, though the pedestrian may be the man who works at the next desk to yours, or a desk higher up. You love the boss for giving you the chance.

The industrial air is thick today with the cries of the inventors of various " systems " of paying wages, hawking the advantages of their wares. A man hardly feels justified in calling himself an " industrial engineer " or a " production engineer " or an " efficiency expert " until he has developed some new kind of bonus or premium, and added another wrinkle to the familiar curves showing the operation of the standard systems. And yet what they all amount to is simply an expedient for paying above the market rate, and on some basis more or less directly connected with the employee's output. Where the nature of the work permits, as in factory production, some kinds of clerical work, and selling, the connection is made as direct as possible, and the bonus is in some way made proportionate to the increased output or sales. In other cases an indirect connection is established; but in all cases the aim of the buyer of labor is to pay the market rate plus something added for unusual diligence and success.

As these " wage systems " are all aimed at the same thing, to arouse the enthusiasm which leads to efficiency, their relative value depends upon the success with which each accomplishes this purpose. Their success depends upon the conditions under which each is introduced and maintained. That system is the best which under given circumstances produces the maximum efficiency with the minimum cost and friction.

The earliest method used for this purpose was the ordinary piece rate. This permitted the exceptional workman to earn a daily wage somewhat in excess of that currently paid. It got as high a degree of efficiency as the workman was able to devise for himself. It was easy to introduce, and worked well — until the management began to feel that the men were earning too much, and proceeded to cut the rates. The succeeding history of this process is too well known to call for narration. Its inevitable result was to call the unions to the protection of their members from this form of injustice; and the result is that today, unless there are the strongest guarantees that the rates will not be cut, the unions are in general opposed to the system. Any change from day rates to piece rates, unless most carefully made, is apt to arouse the opposition of the workmen; and if it is carried through in spite of them, they will take it out in soldiering, so that the effort to get greater production is defeated. One big concern obviates this by forbidding its employees to earn over what it considers a fair day wage. The men are all on piece work, but when they have earned what the company says they should, they are expected to loaf. Of course, they simply stretch out the time on each job so as to come out even at the end of the day. This is about the worst possible system, both for the management and the men.

Many progressive concerns have improved on this by giving a basic guaranteed day rate, with an addition for each increase over the normal production. They have added to this a systematic course of instruction, so that their employees may increase their output to the limit. A big department store in Boston pays its saleswomen a wage based on a certain amount of sales per week. It runs a school of salesmanship. When the clerks get over their minimum they are paid a commission in addition to their week's wages. When this commission has been earned regularly for a few weeks, the basic rate is increased, and again a commission paid for the excess of sales over the new minimum. A great magazine publishing house pays its typists $8 per week for so many hundred square inches of typewriting, and 25 cents a hundred inches for all over that. The result is that the average earnings of its typists exceed $12 a week. This company also maintains an elaborate school where the best way of doing everything in all its departments is continually taught both to new recruits and to old employees. The spirit here is of the finest, and it pays the company many times over in increased output.

The Towne-Halsey premium plan is another system easy to introduce and maintain, and productive of results. As used originally by the Yale and Towne Company, it consisted in setting a standard time in which a job should be done, based on the best time in which it had been done in the past by an average man. Then the workman was given half or one-third the time he saved in doing the job. If the standard time was eight hours, the rate

30 cents per hour, and the man did it in six hours, there was added to his regular wage, 6×30 cents, or $1.80, plus one-half 2 × 30 cents, or 30 cents, making a total for the job of $2.10, or 35 cents per hour. The man got a higher rate and had in addition two hours to apply on another job on which he could be earning the same or a higher rate; the firm's overhead was less, its labor cost was lower, and it was under no temptation to cut the rate. There was no objection from the unions, and everybody was happy — until the men found a way to beat the company in setting a rate on new work, and made such excessive wages that a modification became imperative.

The trouble with this system came in the method of setting the standard time. That was left to the men, and of course their tendency was to make the standard time as large as possible. The way it worked, especially on new jobs, is clearly shown by Mr. Taylor:

> Suppose that two men, named respectively Smart and Honest, are at work by the day, and receive the same pay, say 20 cents per hour. Each of these men is given a new piece of work which could be done in one hour. Smart does his job in four hours (and it is by no means unusual for men to soldier to this extent). Honest does his in one and one-half hours.
>
> Now, when these two jobs start on this basis under the Towne-Halsey plan and are ultimately done in one hour each, Smart receives for his job 20 cents per hour plus a premium of 60/3 — 20 cents — a total of 40 cents. Honest receives for his job 20 cents per hour plus a premium of 10/3 — 3 1-3 cents — a total of 23 1-3 cents.

This easy means of getting excessive premiums of course did not long remain undiscovered. There are two ways of meeting the difficulty. One is to reduce the rate at which the premium increases: the other is to set the standard time in a better way. The best known method of reducing the premium is the Rowan plan; the leading exponents of the other method (which was finally adopted in the Yale and Towne plant) are Taylor and Gantt.

The Rowan plan takes the standard time as set by the men, just like the Towne-Halsey. But the premium is figured differently; the workman's share is a percentage of his regular rate equivalent to the percentage of the standard time he has saved.

If the time is eight hours, the rate 30 cents, and the work is done in six hours, the two hours saved is 25 per cent of the standard, the regular wages are 6 × 30 cents, or $1.80, and the premium is one-fourth of this, or 45 cents. In the early stages the premium is usually higher than by the Towne-Halsey plan; but it decreases as the amount of saving increases, with the curious result that when the man saves 90 per cent of the standard time his premium is the same as when he only saved 10 per cent. This decreased gain in earnings, of course, destroys the incentive to beat the management as in the case supposed by Mr. Taylor; but it is equally effective in penalizing honest efforts to make great gains. The first 20 or 30 per cent increase in efficiency is easy for any good man; it is the higher percentages which become difficult; and it is just those higher percentages which are paid for at a lower rate by the Rowan plan.

Nevertheless both the Towne-Halsey and the Rowan plans have at times been strikingly successful, and are in use in many establishments. Their inventors are all leading manufacturers, practical and successful men. Their plans are easy to introduce, standard times are easily ascertained, no suspicions are aroused, the temptation to cut is slight or none at all, and an increased output is invariably obtained.

But their defects are glaring, and it was to remedy these that Mr. Emerson evolved his system. First he sets a standard time partly in accordance with past achievement, and partly in accordance with what an expert time study shows would be right. This standard is called 100 per cent. A workman must reach 66⅔ per cent of this to hold his job. For every increase of efficiency beyond 66⅔ per cent he gets a bonus, very small for the first increases, and becoming larger as he approaches the standard. At 100 per cent he gets 20 cents bonus on the dollar of wages; over 100 per cent he gets one cent for each one per cent. Thus at 140 per cent efficiency the gets a bonus of 60 cents on the dollar. The management can afford this on account of the lower overhead cost per unit of product.

This system involves a little more work on the part of the management than the other in setting the standard time, yet it is conservative and ought not to arouse antagonism. It pays the men a guaranteed base rate, and an increase for any improvement in efficiency, this bonus increasing as the difficulty of further increasing inefficiency becomes greater. It does not leave the loophole for beating the management which exists in the Towne-Halsey plan.

On the other hand, inasmuch as the rate is not set with thorough exactness, it contains the germ of future trouble. Further, the gradual increase in pay, beginning at the first little increases in efficiency, allows the easy-going unambitious workman a chance to get a little better output and stop there, content with his slightly increased wage. There is no powerful incentive to get the best possible.

The Taylor system (and the Gantt, which grew out of it) is based on a radically different set of principles from all these. It sets a standard time for each job with a precision as nearly scientific as the nature of the work will permit. Materials, equipment, processes and methods are perfected first; then the workmen are trained carefully and patiently to the performance of the work in the best way that experts can determine; the result of this process is the standard time. It is what the trained man can do under circumstances made as nearly ideal for him as the management can devise. After the management has done its part, which is considerable, Gantt says to the workman:

"Now we will pay you your usual wages until you have learned to do this in the proper time. We will provide you with an instructor and with all the conditions which are necessary for you to do it in this time, and when you have succeeded we will pay you from 30 to 60 or 100 per cent bonus in addition to your regular wages, depending on the nature of the work; but whether you get up to the standard or not you will never be paid less than your present wages."

The plan known as the Taylor differential piece rate makes the same proposition as to standard time, conditions and instruction, but says to the workman:

"When you have learned to do this in the standard time, we will pay you a piece rate higher than you have had before; but if you fall below the standard your piece rate will be lower. With a high output, you will get higher pay for more pieces; if you fall below, you will get lower pay for fewer pieces." This is in effect a tremendous inducement to high efficiency, combined with a penalty for failure.

These methods, of course, set their standards with due regard to what a capable worker can do permanently without injury to his health, as has been shown in several elaborate investigations. They are strongly selective; they appeal most to the ambitious, the energetic and the intelligent; such workers are brought to a high plane of efficiency and are kept there by the prospect of the entire loss of the bonus if they fall below it. On account of the rigidity with which the standard is set it is impossible to beat the management; and as the gain is shared between the employer and the employee there is no incentive to cut rates, and every inducement to keep them up. The percentage of bonus that goes to the workman is not arbitrary but is the result of experiments made to determine what percentage would get the largest number of workmen up to the standard. And the results of the system when it is applied in its entirety are in some cases so extraordinary as to seem incredible.

But, on the other hand, the Taylor system is the most difficult to develop and maintain. It involves a degree of intelligence and ability on the part of the management which is comparatively rare. Though the results read like a fairy tale, to get them requires an investment of time, money and patience which few feel prepared to make. In addition, there is a tendency at present on the part of the unions to oppose all "efficiency" systems, under which term they hash together everything except straight day rates.

The difficulty with the men, however, is insignificant in comparison with the trouble which the management has with itself. The Taylor system is a radically new departure which calls for an entirely different spirit and attitude of the management toward its responsibilities. It challenges the management to manage; and this is precisely what they are most averse to doing, so long as they can get along somehow or other with the men managing for them. Isn't this a question for every manager to consider?

The problem of the relation of the labor unions to all systems of efficiency is not so hopeless as it seems. The unions have been productive of an immense amount of good; and the evil for which they have been responsible is due partly to the stand of their employers, and to the ignorance in regard to economic conditions and facts in which they have been left by those who ought to know better. Their opposition to piece rates, for instance, is entirely justifiable, in view of the history of this particular method of payment.

On the other hand, their aversion to modern methods of management is chargeable to two causes, both of them bound to disappear; the fear on the part of some of the leaders that with wages paid in proportion to efficiency there will be no further need for unions, and the fear on the part of the rank and file that increased output means a decrease in the number of those employed.

The first type of fear was illustrated by the locomotive engineers, when their president announced flatly to the Santa Fe that the bonus system and the Brotherhood of Locomotive Engineers could not coexist on the same road at the same time. The Sante Fe had to run its trains, so they carried their point, and the engineers are doing without the bonus. Where bonuses are paid there is less occasion to strike for higher wages; and for those whose living depends on strikes or the prospects of strikes, this does not open up a pleasant vista.

Not all labor leaders, however, look at the plans for getting higher wages from this point of view. Some of them see that their unions exist for many other indispensable purposes besides getting higher wages; and that even with the best bonus system there will be the same necessity for organized labor to protect itself against the greed of unscrupulous employers who will succumb to the temptation to cut bonuses as their forefathers cut piece rates. The only way to meet this is by an unvarying and long-continued régime of absolute fairness and reliability in their relations with their workmen on the part of all employers.

The other objection, that increased output means diminished employment, is more subtle; yet the facts of history show the contrary so consistently that the prevalence of the idea must be charged to sheer ignorance.

This ignorance of what history has proved, the employers and the better informed workmen must eradicate. They must show how increased output means, in the long run, lower prices, greatly increased demand, and increased employment to meet the new demand. Also that it means a larger dividend in which the laborer may share, and a lower cost for the products which he consumes; in short, that this idea is one of the most cruel self-delusions from which humanity has ever suffered. It demands an incessant campaign of education.

With the disappearance of these two fears, employers and unions are bound to unite eventually in a common effort to increase the efficiency of production and distribution. They will reduce and perhaps eliminate the hardship which has usually accompanied the period of transition from one stage of efficiency to another. They will eliminate the wasted energy characteristic of ordinary methods of production, and thus increase the total product in which they must all share. They will reduce the friction and waste of disorganized marketing, and they will adjust the balance of supply and demand more carefully and intelligently, so that there will be made just what can be absorbed at the minimum waste cost, and no more. This will keep everybody busy all the time and the industrial millennium will be nearly at hand.

This is no irridescent phantasy, but merely a statement of the probable outcome of the tendency of today to attack and solve intelligently the age-long problem of fair dealing between the master and the man.

THE RELATION OF SCIENTIFIC MANAGEMENT TO THE WAGE PROBLEM

By C. BERTRAND THOMPSON

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THAT the Taylor system of scientific management has made good with manufacturers and employers who know, cannot now in the light of recent history be gainsaid. The sworn testimony of manufacturers before the Congressional Committee on Labor " appointed to investigate the Taylor and other systems of management " [1] is conclusive on this score. The report of the chief of ordnance for 1912[2] with reference to the working of the system in government arsenals is an illuminating and informing document from an unprejudiced source, which settles the question at least so far as machine-shops are concerned. The application of scientific management to other branches of industry has been spreading widely, not only in this country but abroad in Europe and Japan, and always with the same satisfactory results. In spite of the popular confusion of ideas about what scientific management is and the frequent mistaking of various other " systems " for the Taylor system, the success of the latter in its complete applications is now indisputable, and well-informed managers are aware of that fact.

It is not surprising, however, that the mass of laboring men are as a whole quite uninformed and misinformed on the subject. Men who work in plants organized according to the Taylor system know the facts and are quite willing to admit its success from their point of view. But the majority of workingmen have never seen such plants, and in all frankness it must be said that they have been consistently and persistently misinformed, especially by

[1] Special Committee to Investigate the Taylor and Other Systems of Shop Management, The Taylor and other Systems of Shop Management. Hearings, October 4, 1911, to February 12, 1912. Government Printing Office, Washington, 1912.

[2] Government Printing Office, Washington, 1912.

some of their trade union leaders, in regard to the effect of the system upon the health and wages of the men. This propaganda of misinformation is but a variation of the warfare with which the introduction of machinery was met, and it is likely to have the same effect of retarding the further development of scientific management, unless counteracted by a propaganda of facts. A campaign of education of the workingmen is necessary and, if long enough continued, is bound to be effective. Such a campaign, however, must itself be based upon facts; and in this paper I hope to show the bearing of the Taylor system on the "wage problem."

Of the trinity of materials, machinery, and men that constitutes factory organization, the most important factor is men. Though every one recognizes this truth, very few have in the past acted upon it. A great deal of attention has been given to the purchase of materials in the cheapest markets, and the getting of materials best adapted to the processes in hand. And, similarly, much thought has been devoted to the technical improvement of machinery and the introduction of inventions. Every up-to-date concern has its purchasing agents, its inspectors and laboratories, its machinists and inventors; but very few seem to have given particular attention to the most fundamental of the three elements — the men.

In spite of the prevalence of the talk about sanitation, safety, welfare, *esprit de corps*, etc., the most vital point of contact between managers and the men is the pay envelope. There is no solution of the problem of apparently conflicting interests between employers and employed that does not involve fundamentally the question of wages.

What is the relation of scientific management to the wage problem? Perhaps the easiest way to make clear the point at which I hope to arrive in this paper is to review briefly the history of wage systems.

It is rather difficult to say which kind of wages came first — day rates or piece rates. Probably both have existed ever since one man worked for another. Perhaps piece rates came first; for we may imagine that, when our primeval ancestors got together and one of them decided to fish for a day if another would make axes that same day, they would swap products with each other. In other words, each was paying the other for a definite product, which is the essence of a piece rate. In a condition of society in which foresight was not highly developed and complex thought was difficult, such a method was the easier and therefore probably the more common. But when the operations of labor became more complex and the imagination more comprehensive, one would start to do something for another that would necessarily take more than a day. The workman in the meantime would have to live and could not wait until the product he was working on was finished before getting some kind of payment. His pay evidently could not be for a definite product and must therefore have been on a day rate. But whatever the origin and the priority of these rates, it is a fact that they have existed side by side through all historic time.

The idea of payment for work involves the notion of equivalence of value, and this notion has crystallized into the common expression, "a fair day's work for a fair day's pay." These terms are exceedingly vague. A fair day's work seems to mean to most people that the workman shall keep busy for the greater part or the whole of the day, or at least appear to be busy. A fair day's wage in most minds means such a wage as will enable a man to live up to the standard of comfort common among his peers in the community. In primitive conditions if a man would work all day and his employer would pay him for that day's work what was necessary to enable him to live, the sense of fairness was satisfied.

Both of these ideas are exemplified in the parable of the man who went out early in the morning to hire laborers for his vineyard; an hour or two later he went out and hired others; late in the afternoon he hired still others; then at the end of the day each was paid a penny. The men that went to work in the early morning protested that, as they had worked longer, they should be paid more. The master of the vineyard, however, maintained that it was his right to pay what he chose, and his idea seems to have been that whether a man worked one hour or ten he needed the penny in order to live. The workmen were going on the theory that a fair day's work means working all day; the employer on the theory that a fair day's wage is what a man needs.

One obvious difficulty with day wages lies in the fact that, though the wage may be fairly set by public opinion or by organization, the content of a day's work is not by that method established. You may satisfy the workman by giving him what he needs, what he has to have, but you have not necessarily satisfied the employer that the workman has done a fair day's work merely because he has spent a certain number of hours on the job; for after all the employer's equivalent is not as a rule the mere command of the workman's time but a measurable product.

When the day's wage is set by public opinion or by organization, but the day's work is not, there is a tendency for the day's work to diminish gradually to the point where the workman can just keep his job. That this has happened in many cases is a matter of current knowledge, and is one reason for the dissatisfaction of employers with the day wage; for the workmen have sometimes abused their opportunity and have done just the least possible; and their opportunity to do this has arisen largely from the fact that the employer has never really known what a fair day's work is.

When this condition becomes intolerable to the employer, the natural, the obvious thing to do is to pay for the unit of product instead of the time employed. The history of piece rates is well known. On their introduction the employer pays for what he gets and the employee is paid for what he does. Both sides are satisfied and the production increases. The time soon comes when the workman puts forth all the energy he can muster to earn as large a wage for as large a number of units of product as he can possibly produce. The employer is highly pleased with the increased production, but soon begins to worry about the wages he is paying. Then comes the inevitable cut. The workman has himself established the rate of production of which he is capable, and the employer figures a piece rate on this production which will just provide the man an average living wage. One or two cuts are usually enough to show the workman the futility of putting forth his best efforts under such a system; and the advantages of piece rates have in many cases been destroyed in this way by the greed and the injustice of the employer. The opportunity for greed and injustice, however, arose from the fact that neither the employer nor the employee really knew what a fair day's work was.

It is generally recognized today that both day rates and piece rates are clumsy and inefficient, for the reason that the workman will frequently beat the day rate and the employer will cut the piece rate. This is made possible and practically inevitable by the ignorance on both sides as to what is either a fair day's work or a fair day's wage.

Many efforts have been made to avoid both horns of the dilemma. From the fourteenth century on, legislation was depended upon. Legislation which set wages to meet the conditions existent at the time it was passed was fairly efficient; but the rapid changes in industrial conditions were not followed by equally rapid changes in legislation; with the result that the laws of the market prevailed eventually over the laws of the legislature. In fact near the beginning of our modern era of industrial organization existing legislation had actually become obsolete, and the attempt to regulate wages by act of Parliament was, under the influence of the ideas of Adam Smith, formally and officially given up.

Adam Smith's optimistic philosophy to the effect that if men were left alone the compromise effected by the conflict of their self-interests would work out to the greatest satisfaction of all, was not justified by the event. The Statutes of Labourers, though poorly fitting the conditions at the beginning of the nineteenth century, were some slight protection to the workingman. Though originally intended to set a maximum beyond which wages should not go in periods when labor was scarce, their application changed entirely in the course of two centuries, and in the early years of the industrial revolution they established at least a minimum wage and, when they were repealed, the workingman was left at the mercy of his employer, and from his relatively weak position was forced down to and below the limit of endurance. His only resort was organization.

This was the time at which labor unions in the modern sense of the term established themselves, demonstrated the necessity of their existence, and got the foothold which they maintain in England and America and many other countries today. They were the answer of the under dog to the insolent assertion of prerogative on the part of the employers to establish any wages and any conditions which they chose to impose.

Labor unionism has not been exempt from the usual tendency of movements to go too far in the direction in which they started. The unions were organized originally to protect the employee against the aggression of employers; but as they began to feel their power and to exercise it, it was inevitable that in the course of a few decades they should turn the tables on the employers and themselves become the oppressors. They discovered that they could tell the employers what the latter must pay but that the employers had no means of determining how much work the employees ought to do. The policy of restriction of output has been based on many arguments, but the most primitive and potent reason for it is the selfish tendency of human nature to give as little as possible for what it gets. When the employees through organization acquired the power to determine wages and the employers in their ignorance had no means of determining a fair day's work, a minimum output was the inevitable consequence.

If in some cases this tendency was counteracted by a sense of fairness and mutual dependence, in many more cases it was aggravated by the feeling of conflicting interest and inherent hostility between the two parties. In fact this feeling of hostility has been so prominent as to mislead many men into the idea that to solve the wage problem meant merely to establish cordial relations between the employer and the employee. Many means to this end have been proposed and tried.

One of the earliest attempts to bridge the gulf was to leave the method of payment unchanged but to secure the coöperation of the workingman by the psychological means of kindness, fair treatment, and the development of a spirit of loyalty and of personal satisfaction in doing the job right; this is the basis of the so-called "welfare movement." Experience has shown that where day wages are paid and there is no established method of determining and enforcing a day's work, the best that can be done is to try to develop the spirit of coöperation by such methods.

There are many objections, however, to most welfare schemes. One reason for their frequent failure is the fact that they are largely personal to the man who instals and develops them. He is unable to resist the temptation to impose upon the workingmen his own ideas of what is best for them. Often also he is arbitrary and capricious. He looks at welfare work as a gratuity on his part which he can extend or withhold at his convenience. Sometimes also, in the excess of his zeal, he carries his welfare activities down to the most personal details of his employee's domestic management and arouses a feeling of strong resentment. But more important than these objections is the common and natural opinion of the men that the firm which can afford to maintain welfare institutions can just as well afford to pay better wages, and that they (the men) have a right to decide for themselves how these wages shall be spent. And, finally, welfare schemes often bear the aspect of charity to the employee or of advertising for the firm; and in either case they come speedily to destruction.

Some manufacturers have said: "If welfare is charity and charity is disagreeable to the men, let us be businesslike. The success of our concern is the joint product of the men and the management, and it is businesslike for the management to share the profits with the men. We will limit our profits to 10 per cent and all over that we will divide among our employees."

The history of profit-sharing has been as discouraging as that of welfare movements. One or two conspicuous successes may be pointed out; but, on the whole, it is a history of failure. The recent report of the British Board of Trade on Profit Sharing,[1] bringing its history in Great Britain up to date, shows conclusively that the best results accomplished in a few establishments consist merely in a general better feeling toward the management. It points out that definite and substantial in-

[1] (British) Board of Trade (Labour Department), Report on Profit Sharing and Labour Co-partnership in the United Kingdom. Wyman & Sons, Ltd., London, 1912.

creases in output or in wages are rare, if they exist at all, and that at the best it is extremely difficult to establish a relation between such improvement as has been observed and the method of profit sharing. The reasons for this are numerous: in the first place the reward is too remote and uncertain; the workman may wait a year for his dividend and then find that there is nothing to be divided. He is usually suspicious that the accounts are being juggled in the interests of the management. In any case he finds his share of the profits ridiculously small in proportion to the increase of energy he may have put into his work. The most conspicuous example of this is the scheme of interesting the employee in the concern by allowing him to purchase shares; a holder of five shares in a company that has an issue of twenty million may double, treble, or quadruple his output and efficiency without producing the slightest effect upon the dividends on his shares. Beyond and behind all these reasons is the fact that people generally do not consider profit sharing fair. Profit sharing is a form of partnership, and a partnership should be for worse as well as for better; but the profit sharing scheme divides part of the profits among the men and imposes all the losses on the management. Such a scheme is not and cannot be permanently satisfactory.

As these plans have failed one after another, other schemes have been proposed to take their place. It was felt that the interest of the workman, which the usual profit sharing scheme had failed to arouse, might be secured if the workman were to get more quickly the benefits of his increased activity. A straight piece rate which would secure him such a benefit would carry with it the temptation to the management to cut; so the scheme was evolved of setting a standard time, based on experience, in which work could be done, and then dividing with the workman any time saved by the latter over the standard time. This amounts to notifying the workman in advance that, after certain earnings on a piece rate basis have been reached, his rate will be cut one-half. Crude as it is, this premium system has been successful for limited periods in many cases. The management makes its cuts once for all in advance and the workman knows exactly what is coming. Unless some cut is made which is not scheduled, the men will work under this scheme with considerable interest and profit both to themselves and to their employer.

But this scheme also usually fails in the long run because it has not cured the fundamental weakness of both day and piece rates: to wit, uncertainty as to what is a fair day's pay and ignorance as to what is a fair day's work. In short, none of the current and historic methods of wage payment satisfy the popular demand for equivalence incorporated in the expression, a " fair day's work for a fair day's wage," for the reason that neither side of the equation has been until recently definitely determined. Where there is only uncertainty as to what constitutes either a day's work or a fair wage, there can obviously be no satisfactory solution of the problem.

So far as I know, the first recorded successful attempt in history to determine either side of the equation accurately and scientifically was made by Mr. Frederick W. Taylor at the works of the Midvale Steel Company thirty years ago. As foreman in the plant, Mr. Taylor found himself involved in the usual conflict over wages; and he observed that no matter what scheme he tried, he did not secure permanent satisfaction among the workmen or the employers. Nobody really knew what ought to be expected as a day's work. He set out, therefore, to devise a method to determine accurately if possible what a fair day's work was, and then to pay for the performance of this work in proportion as it exceeded the ordinary commonly accepted day's work on which the ordinary rates of pay were based.

As the result of several years' study and experimenting, Mr. Taylor evolved the method of time study and the differential piece rate which characterize his system of scientific management today. Where the differential piece rate prevails, there are two rates for each product: one known as the low rate and the other as the high rate. For example, time study shows that it is possible to produce 10 units of a certain product in a day; for each of these units the workman gets 35 cents, provided he produces the 10. But, if he produces less than 10, he gets 25 cents per unit. If he produces 8 units, he gets $2.00; if 9, $2.25; if 10, he gets, not

10 × 25 cents but 10 × 35 cents, or $3.50. This obviously provides a strong incentive to a man to accomplish the production on which the high rate is based.

The essential feature of the system is, however, that the standard production (known technically among the Taylor group as "the task") must be based on an accurate time study; and it must be determined with the same impersonal and dispassionate desire for truth that actuates the scientist in his laboratory. The work to be studied is divided first into its elementary operations, and the time in which these operations can be performed after methods and materials have been standardized, is ascertained by a long-continued series of tests on an average man fitted for the job under observation. The requirements are intelligence, patience, analytical power, and the capacity for accurate observation on the part of the time study man (for whom we should like to adopt the French name *chronométreur*), and honesty and skill on the part of the observed. Given these qualifications, the determination of a fair day's work is a mere impersonal study of a physical fact. It is simply answering the question how long it takes to do a given thing, and the answer does not depend on any man's personality: it makes no difference whether the time study is done by a union leader or by the owner of the works, by an old man or a young woman; personal interest plays no more part in it than it does in the measurements of an astronomer or physicist.

Time study then, when made by competent men trained in its technique and the technique of the industry under observation, defines at least one side of the equation: namely, the content of a fair day's work. Such study, when properly made, includes allowance for necessary rest and other necessary delays. When these facts are determined and a mimimum time established, the conclusion is a positive, impersonal fact, the result of observation; it is not a matter of any one's opinion or interest, but a fact established in accordance with the approved methods of scientific investigation.

Time study, while but one element of the Taylor system of management, is typical of that system in its scientific method; and this characteristic method is that which has gained for the Taylor system the name of "scientific management." When such time study is instituted in a plant, it involves the standardization of administration and of equipment, materials, and methods, and therefore implies a radical and revolutionary reorganization of the plant. The establishment of a fair day's work (the task) and the institution and maintenance of conditions which will enable the workman to accomplish this work and earn the increased compensation known as "the bonus," cannot be done successfully in a plant managed by the old methods. It requires more than a new mechanism; it requires a new mental attitude on the part of the management, the attitude of the scientific investigator, which is as free as possible from personal interest, and which assumes nothing that cannot be ascertained and proved; it means a new moral attitude — a substitution of the passion for truth for the reliance on guess work, ignorance, and bluff which has heretofore prevailed.

The usual method of setting piece rates makes no claim to being scientific, even if in some cases it may be honest. Some plants establish their rates as the result of a series of observations of the time similar jobs have taken in the past; but as these observations show widely varying times for the same work, an average is taken which is simple arithmetic and nothing else. Others set a rate on the basis of what they can afford to pay in the prevailing state of the market. New rates are almost always set by some one's "judgment" which is merely a term for a more or less experienced guess.

For all these methods the Taylor system substitutes the method of the scientific observer. If the observer, being human and in some cases more in sympathy with the management than with the men, allows his scientific judgment to be swayed by his desire to make the day's work as large as possible, he cannot do otherwise than overstep the mark to the extent of setting a task which cannot be accomplished. But this process is self-defeating, for if the task cannot be made, the bonus cannot be earned, and the men will not attempt to do the new day's work. The management thereby loses more than the men, and the intrusion of a greedy bias kills the goose that lays the golden egg.

The Taylor system therefore puts a firm foundation under one pier of the arch which is to bridge the gulf between employer and employee, in that at least it makes it possible to determine what is a fair day's work. What does it say about a fair day's wage?

Scientific management does not today attempt to establish what is a fair day's wage. It takes the prevailing rate of wages in the community and then proceeds to add to that a bonus in proportion to the achievement secured in excess of the ordinary achievement in that community. This process, however, leaves the basic rate to be determined as before; that is, by the ordinary daily bargaining in the market. We have seen that in this bargaining the disadvantage at which the workman is placed by his dependence upon his work for a living has subjected him to abuse at the hands of his employers. Legislation has failed to determine a fair day's wage. It can set a rate of payment, but, until it sets the amount of work that is to be done for that rate and enforces the performance of the standard amount of work set, the rate is futile. In this fact lies the fundamental weakness of mimimum-wage legislation. The law cannot compel an employer permanently to pay $8 a week, unless it can also assure him workmen who can and will produce at least $8 worth. Experience has shown that the good-will of the employer cannot be depended upon permanently to maintain a fair day's wage. Public opinion also has failed, for the reason that, while in an abstract way each man wants justice for the other fellow, he is not willing to make much personal sacrifice in the way of paying higher prices for the other fellow's product. Each member of the public wants to buy everything as cheap as he can get it, even if this cheapness involves some one's else low wages.

In my opinion it is as true today as it was a century ago that the final resort of the workingman is in the collective force of organized labor. Under scientific management or any other system, the workmen must depend upon their combined power to enforce a mimimum wage. But this policy will not succeed in the future any better than it has in the past, unless the demand for a minimum wage is accompanied by the promise and guaranty of a quantity of work which will warrant that wage. There is no possible harmony between scientific management, large output, and the social interest on the one hand, and mere unintelligent force, restriction of output and class interest on the other. But the labor union which will adopt the policy of establishing a minimum wage as a basic rate on which a bonus, determined by the conditions of the industry, shall be paid for the performance of a proper day's work, and which, in addition, will assist if necessary in determining what a proper day's work is, and in enforcing the performance of that work on the part of its members, is acting at once in its own interest and in that of society. This would be a long step toward the solution of the wage problem and would help to bring about that coöperation of employee and employer which we all desire and hope for but rarely see.

It is something more than a dream that labor unions are sooner or later going to take over scientific management and make it their own. They have already established their right — by force, to be sure, as most rights are established — to determine a minimum wage. They have established their right to safe and sanitary conditions of work. There are cases on record where they have gone to the management and said: " You will have to scrap that obsolete machinery and put in new machinery." They have complained to state commissions of the obsolete equipment of railroads. They have even struck to compel the management to instal the Taylor system, and have done this, not because they were primarily interested in large output or higher profits for the management, or even in a lower cost to the consumer, but because they were intelligent enough to realize that in industry as elsewhere, knowledge is the foundation of justice, and only that method of management based upon knowledge can answer permanently the question of fairness.

Along this line a union can and should say to its employer: " We do not care how much profit you can make out of your business but we insist upon having fair wages, and if you cannot make enough by your present methods to pay us fair wages, you must, if you want to employ us, organize your business on the most modern and scientific plan, so that you *can* pay us."

When labor unions arrive at that point of view, as they will when they get a type of leadership which is more interested in securing the welfare of their members through peaceful progress and coöperation than in earning their salary by fomenting strife — when they take over scientific management and say: "We believe in this and will help it because it means larger output, lower cost to the consumer, higher wages for ourselves, prosperity for the employer, general satisfaction and a higher standard of living; and because it is good for us we insist that you shall adopt it" — then we shall have a type of coöperation which is permanent because it involves fundamentally the welfare of both parties. And in this I believe I see as near a solution of the wage problem as we are likely to reach under our current form of industrial organization. This involves not the weakening but the strengthening of organization of both employers and employees, and the assumption of greater responsibility on both sides. It can come only with the increase of knowledge and under the predominating influence of a desire for truth and justice; and as usual the world is being driven toward truth and justice by the stress of the conflict brought on by ignorance and injustice.

SCIENTIFIC MANAGEMENT AND THE WAGE-EARNER

By FRANK T. CARLTON

ALBION COLLEGE

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EFFICIENCY programs are attracting much attention in this country, at the present time, because nearly all of the great expanse of land found within the borders of the United States has been taken up and the vast natural resources of the nation have been tapped. We are entering a period of diminishing returns; and a period in which increasing attention will be directed toward small economies that were not considered worthy of notice a generation ago. " The cream has been skimmed off the pan of our natural resources." Also, factory legislation, laws as to hours of labor, and the activity of labor organizations are tending to raise the level of wages and to increase the expenses of operating a business. As a consequence, employers are being stimulated to adopt more efficient methods.

Many indications point to the conclusion that modern industrial nations are passing over the threshold of a new era in industrial and social progress. We are about to enter upon a period marked by the rapid increase in the use of machinery and of carefully planned methods of doing work. Witness, for example, the glass-bottle blowing machine, the giant mail-order house with its systematized large-scale distribution of goods, and the farmer's use of engines drawing gang-plows. The term " industrial revolution " has heretofore been applied to the rapid adoption of new tools and machines.

" Social invention " is to be typical of the epoch just ahead. And what may be tabulated under the head of social invention, efficiency engineering, or scientific management ? Efficient combinations of labor-saving machines, accurate information as to the time and energy required to do specific jobs, motion studies of different craftsmen, and psychological studies of the kinds of incentives which most effectively stimulate workers to do their work efficiently — these are some of the important planks in the efficiency program.

Scientific management or efficiency engineering is concerned with two somewhat interrelated matters. The first is efficient systematization of the work in a given factory from the engineering or the mechanical point of view — the routing of the work, proper cutting speeds, the care of tools and machines, and the like. The second factor is psychological in its nature; it relates to the effective methods of "energizing" the workers by providing potent incentives and by stimulating interest in the work. The first is the more simple of the two problems but it cannot be carried out successfully without solving the psychological problem. Since technical improvements in machine-shop methods increase the per capita output of the wage-earners, these scientific methods will doubtless be introduced, as were machines, in spite of opposition. Efficient methods of doing work will sooner or later displace less efficient methods just as, for example, the steamboat has displaced the sailboat, the automobile is displacing the horse upon the streets of our cities, and the giant drop-hammer has displaced the village blacksmith. The transformation may be retarded; but the constant pressure of economic forces will finally break down all opposition.

But the second portion of the program of the efficiency engineer cannot be forced through. It cannot be secured by coercion; it can be effectively carried out only when the wage-earners harmoniously coöperate with the managers in working out the proposed plan. The fundamental problem of efficiency engineering centers around the treatment of the wage-earners. It is more a problem concerned with the relations existing between the employer and his employees than it is a problem of bookkeeping or of the care of machines or of the selection of tools. The pioneer and leading exponent of efficiency engineering, Mr. F. W. Taylor, writes: "This close, intimate, personal coöperation between the management and the men is of the essence of modern scientific or task management." And Harrington Emerson asserts that to "establish rational work standards for men requires, indeed, motion and time studies of all operations, but it requires in addition all the skill of the planning manager, all the skill of the physician, of the humanitarian, of the physiologist; it requires infinite knowledge directed, guided, and restrained by hope, faith, and compassion."

In theory, according to its advocates, scientific management stands for increased productive capacity without increased effort; it aims to do away with lost motion and useless movements. It means maximum results with a minimum of effort; it does not mean "frenzied production." Now, these objects are certainly worthy of approval; and, consequently, opposition to efficiency engineering must arise because of the methods employed in carrying out the policy. Our attention evidently must be directed toward this pertinent inquiry: How, then, can this "close, intimate, personal coöperation," of which Mr. Taylor speaks, be secured?

It is perhaps worth while at the outset to call attention to the obvious fact that the man who is "working for himself" does not object to methods or systems which lighten his work. The farmer is glad to obtain a tool which will increase his productivity. Even the conservative wife of the farmer is not adverse to the installation of a new or better pump, a cream-separator, or some scheme which will save steps. Why, then it may be asked, does the wage-earner so frequently resist the introduction of new machinery or of new and scientific methods of performing work? The farmer and the farmer's wife do not fear that the new machines or methods will cause them to lose their positions, or that they will be called upon to do much more work for little more pay. They believe, on the contrary, that their income will be increased and the length of their working-day reduced. In short, they are confident that the results of their efforts will be multiplied. On the other hand, the wage-earner feels instinctively, too often as the consequence of past experience, that the system of scientific management is some more or less subtle scheme to advance the interests of his employer at the expense of the workers individually or as a class. How can the viewpoint of the worker be modified until it coincides in this particular with that of the farmer or with that of the man who is "working for himself?" This points to another fundamental problem for the efficiency engineer to solve.

The wage-earner is today insistently demanding that a portion of his share in the advantages accruing from the introduction of improved machinery and of scientific management be given to him in the form of a shorter working-day. His conception of a desirable form of society in the twentieth century is not one in which a certain number of individuals work at high speed during a long working-day but one in which all work during a short working-day. There are, obviously, at least two alternative methods which may be pursued in producing a given quota [1] of economic goods and services: a small number of men may be employed for a long working-day or a larger number for a shorter working-day. From the standpoint of the wage-earner observing a large and apparently growing army of unemployed, the second alternative is by no means repulsive. His ideal is not necessarily maximum productivity per worker per day; but a condition in which work and recreation are blended for each and every individual. And, if economics is "the reasoned activity of a people tending toward the satisfaction of its needs," shall the economist confidently assert that the wage-earner's ideal is one worthy only of contemptuous rejection?

If scientific management has great possibilities, the effect of its introduction may not be unlike that caused by the displacement of the hand tool by the machine. Not only may increased production be anticipated, but also the displacement of workers, temporary unemployment for many, and a multitude of industrial evils which accompany every important readjustment in the sphere of industry. The introduction of scientific management bids fair to cause "another intensive, resistless reorder-

[1] The assumption of "a given quota of economic goods and services" is applicable only to a static state and, in so far as the argument of the writer is based upon this assumption, it does not apply to a dynamic economic condition in which the quota of economic goods and services which can be absorbed by society is constantly increasing. — ED.

ing of industrial life."[1] And the wage-earner, with his skill as his sole capital, with only a small savings account or none, and with a family to provide for, is justified in manifesting alarm. A "resistless reordering of industrial life" usually means, for many wage-earners, unemployment and uncertainty. John Stuart Mill asserted that "hitherto it is questionable if all the mechanical inventions yet made have lightened the day's toil of any human being." Will scientific management do so?

Before passing to a consideration of the conditions which are requisite for the successful outcome of scientific management, it seems appropriate to notice some of the points made by Mr. F. W. Taylor in his recent book, *The Principles of Scientific Management.* These points have a direct bearing upon the later discussion of the topic under consideration.

Mr. Taylor declares that under an adequate system of scientific management, "each man should daily be taught by, and receive the most friendly help from, those who are over him, instead of being, at the one extreme, driven or coerced by his bosses, and at the other left to his own unaided devices." In this manner, it is urged, "systematic soldiering" on the one hand and injurious speeding-up on the other hand will be avoided. But is it reasonable to expect that the workers will willingly and contentedly leave the determination of the definition of systematic soldiering and injurious speeding-up to the inevitably prejudiced judgment of their employers?[2]

The model workman, from the standpoint of the typical efficiency engineer, is the vigorous man who freely expends all of his

[1] While it is true, as the writer suggests, that the introduction of scientific management means eventually "a resistless reordering of industrial life," it appears to be assumed that this reordering must come about quickly. The fact is, as has been pointed out by Mr. Taylor and as is evidenced in experience, that the effect of this development of management upon industrial conditions is and must necessarily be gradual from the nature of the factors involved: the necessarily slow development of the science of each industry; the weight of the inertia both of management and men to be overcome; the scarcity of experts available to extend the system; and numerous other reasons. — Ed.

[2] The writer here overlooks the fact that the task to which he refers is not based upon any one's judgment, either that of the employer or of the employee, but upon accurate time study. — Ed.

surplus energy during working-hours and who utilizes his non-working-hours only for recuperation and preparation for another day's work.[1] It is not the purpose of efficiency engineering to allow the worker to depart from the door of the factory at night with more than a minimum of surplus energy for recreation, for family life, for civic duties, or for trade-union activities. In short I find little in the actual program of efficiency engineering which indicates that the wage-earner is to be given opportunity for individual development — and I have not overlooked the various paternalistic endeavors classified as welfare work. A human machine rather than a man is the "model workman." I also find little, or more accurately nothing, in Mr. Taylor's book which indicates that he appreciates or sympathizes with the viewpoint of the wage-earner.

Mr. Taylor informs us that a long series of experiments has shown that an increase in wages up to 60 per cent beyond the wages usually paid has a good effect upon the men. But, "on the other hand, when they receive much more than a 60 per cent increase in wages, many of them will work irregularly and tend to become more or less shiftless, extravagant, and dissipated. Our experiments showed, in other words, that it does not do for most men to get rich too fast."[2] But what of the efficiency of the

[1] Cf. this statement with Mr. Taylor's definitions. The following quotation is from his "Principles of Scientific Management," page 9.

"The principal object of management should be to secure the maximum prosperity for the employer, coupled with the maximum prosperity for each employee.

"The words 'maximum prosperity' are used, in their broad sense, to mean not only large dividends for the company or owner, but the development of every branch of the business to its highest state of excellence, so that the prosperity may be permanent.

"In the same way maximum prosperity for each employee means not only higher wages than are usually received by men of his class, but, of more importance still, it also means the development of each man to his state of maximum efficiency, so that he may be able to do, generally speaking, the highest grade of work for which his natural abilities fit him, and it further means giving him, when possible, this class of work to do." — Ed.

[2] Mr. Taylor's observation on this matter has been amply confirmed by experience. One conspicuous example should be sufficient. The man referred to in "Shop Management" as "Schmidt," the pig-iron handler, has had his record traced recently, and the investigation showed that the unusual and exceptional earnings he made were used largely in drinking. — Ed.

corporation which receives large increases in its rate of profits? How do such increases affect the alertness of the managers, the adoption of improved methods, machines, and safety appliances?[1] Can the workers or the consumers afford to allow an employing corporation to increase its rate of profits? If so, how rapidly and how much? This is an unworked field of efficiency engineering. And our efficiency engineers are not enthusiastically interested in investigations of this sort.

"Soldiering" on the part of wage-earners in the United States is alleged to be a menace to the prosperity of every establishment and of every wage-earner in the nation. The causes of soldiering, according to Mr. Taylor, are three in number; but these are readily reducible to two. These two causes may be stated as follows: (*a*) the general acceptance of the lump-of-work doctrine; (*b*) the lack of scientific management. I have elsewhere[2] shown that the lump-of-work argument cannot be so easily laughed out of court as some economists and employers would have us believe. The workingman is interested in tomorrow's job and wages rather than in some indefinite benefit to society next decade.

> The knowledge that a certain policy, if pursued by all for a period of years, will inevitably bring about reductions in the wage scale does not appeal to the average wage-earner with a family to feed, clothe, and shelter, in the direct and forceful manner that the immediate probability of slack work does. He sees that by "nursing" a particular job he may work longer or another fellow-workman may be employed. This is something tangible, the other is a remote and uncertain possibility. Immediate work for John overshadows the vision of a chance of future employment for Tom, Dick, and Harry, and other unnamed and unknown individuals.

Mr. Taylor directs attention to the shoe industry. The introduction of machinery into this industry has undoubtedly cheapened the price of shoes to the consumer; and the workers can, as a consequence, afford to buy more and better shoes. And it may also be true "that there are relatively more men working in the

[1] Inasmuch as the increased profits referred to cannot persist in competitive conditions, in the absence of managerial alertness, this alertness is in such conditions automatically maintained. In most cases it is precisely the fact that the manager has the acquisitive or business temperament that is indispensable to his being manager instead of man. — Ed.

[2] *The History and Problems of Organized Labor*, pp. 132–134.

shoe industry than ever before." But it is also a fact that many workers were adversely affected by the introduction of shoe machinery. That great and spectacular outburst of unionism — the Knights of St. Crispin — was not the fantastic result of purely imaginary dangers. Many men with wives and children to feed, clothe, and house saw their trade, that is, their means of earning a decent livelihood, being ruined; they saw — and their vision was not defective — the menace, at that time and place, of cheap labor. Their problem was individual and immediate, not social and a matter of future welfare.[1]

The non-social lump-of-work argument is closely paralleled by what may well be called a lump-of-capital argument. Many a corporation composed of individuals who are not in business for their health has obtained a patent upon some new appliance which would cheapen the cost of production but necessitate the scrapping of much valuable equipment; and, consequently, with the aid of our antiquated patent laws such corporations have quietly shelved the patents. The attitude of the capitalist in such a case is not very dissimilar to that of the workingman who opposes the introduction of machinery or of new processes which threaten his trade or his lump-of-labor. In addition to the prevention of soldiering on the part of workingmen one of the problems of a well-rounded program of efficiency engineering would be to prevent the shelving of new appliances and machines, and, perhaps, to call for a modification of patent laws. But so far as my knowledge goes, our efficiency engineers have not paid much attention to this important matter.

With these illustrations before us, you are asked to direct your attention to the requisites, in the judgment of the writer, for a successful form of efficiency engineering or of scientific management.

[1] The writer is correct in calling attention to this fact which has apparently hitherto been overlooked by most of the exponents of scientific management. It is on account of the important personal bearing of scientific management that the problem of educating the laborer is so much more difficult than from a strictly logical point of view would appear to be necessary. — Ed.

All careful and disinterested students of efficiency engineering will doubtless admit that such systems are advocated by the employer, that the employer instituting them expects to direct their operation, and that the systems are adopted primarily for the benefit of the employer. The problems connected with the various systems are viewed from the standpoint of the employer and capitalist. Benefit to the wage-earner is perhaps considered to be an incidental advantage; but it is a secondary matter. The bright and shining goal — the attractive lure — is lowered costs and increased profits, rather than better workmen and citizens, or more leisure and culture and enjoyment for the toiling mass and their families.[1] Is it reasonable to expect that the wage-earners, organized or unorganized, will grow enthusiastic over a lop-sided system of scientific management? If, as Mr. Taylor declares, "close, intimate, personal coöperation" is required to "energize" a plant, efficiency engineering cannot reach a high degree of success while the workers distrust the motives of the employer, or as long as the workers in the plant are convinced that the employer is trying to get more work out of them without proportionally increasing their pay.

The average American citizen looks askance upon an arbitrary government which is in no way under the control of the mass of governed. The despot, whether enlightened and benevolent or not, would be regarded with suspicion and would not be tolerated. Men have repeatedly and vigorously objected to arbitrary action on the part of government. And for centuries the western world has been moving toward democracy. The Louis XIV view of government is obsolete, but absolutism in industry is still characteristic of the business world. Will not, therefore, the average wage-earner, granted political privileges but shut out of the councils of industry, distrust the management of the business in which he earns his daily bread. He will certainly see in the plans of the employer schemes for quietly and effectively squeezing the laboring man. The workers in our shops, factories, and

[1] It is neither a long nor a difficult course of reasoning which connects lowered costs, increased profits, and higher wages (the latter unfortunately omitted by the author) with "more leisure and culture and enjoyment for the toiling mass and their families." — Ed.

mines can no more be expected to look with favor upon arbitrary changes concerning which they have not been consulted, than can the average citizen of today be expected smilingly to abide by the rulings of an arbitrary monarch.

The day of the individual entrepreneur is of the past, not of the present nor of the future. We may regret his going; we may vociferously assert that he was superior to the giant corporation with its collection of mutually independent units, and we may argue that the rivalry between entrepreneur and entrepreneur is essential to business progress and industrial efficiency; but the corporation is here, and here to stay. Likewise, the day of individual bargaining with the isolated worker is passing. Employers may strive to delay its going; but in vain will be the effort. Professor Commons has pointed out that unorganized as well as organized workers are willing to strike for the right to bargain collectively. "It is their desperate recognition that the day of individual bargains is gone for them." It is safe to assert that efficiency engineering will not be successfully introduced and maintained by union-smashing corporations demanding individual bargaining with workers, because "close, intimate, personal coöperation between the management and the men" obviously is impossible under such conditions.[1]

Organized labor is definitely committed to the method of collective bargaining; and both organized and unorganized wage-earners recognize that, except in a few highly skilled trades and in the case of farm laborers, the individual bargain leads toward a sweating system. The employer who demands the continued use of the individual bargain, whether the demand is made in the name of liberty and the freedom of contract or in the name of efficiency, becomes an object of suspicion. Individual bargaining is productive of distrust rather than of harmonious coöperation.[2] And consequently efficiency engineering can only hope to

[1] Thus far scientific management has been introduced mainly in establishments which practise individual bargaining exclusively and, in spite of the theory, it is evident to any student of those organizations that "close, intimate, personal coöperation between the management and the men" has been secured. — Ed.

[2] As may be inferred from the previous note, this statement is not borne out in experience. — Ed.

succeed, in the long run, in energizing workers by utilizing the collective bargain. And accepting the collective bargain means the partial admission of the representatives of the workers into the councils of the employers. It is a tentative step away from autocracy in business; it is a step toward putting industry upon a peace instead of a war footing. Collective bargaining and the admission of the workers into the councils of the management are essentials of close coöperation between the management and the employees. But the leaders in the movement for efficiency engineering have not, as yet, given this fundamental fact definite recognition.

Successful scientific management — management which possesses the qualities demanded by its advocates — must necessarily cast aside the old incentives such as coercion, and the constant nagging and prodding by the foreman. Furthermore, it must be so directed that the workers will be convinced that it is to their interests to accept the planning-room's methods and program, and to follow the system outlined by the experts in charge of the work. But, without organization and the collective bargain, have the workers any reason to believe that the program of the efficiency engineer will benefit them? If the history of the introduction of machinery, or of the course of events in the steel industry since unionism was driven from the steel mills offers any useful lessons, the obvious conclusion, in the judgment of the writer, is that the workers must unite upon both the industrial and the political field in order to derive any considerable share of the advantage of efficiency engineering. Without united and aggressive action, it may be anticipated that the workers will be shorn of the major portion of the direct benefits which may result. Mutual respect and coöperation between employers and employees are the fruits of equality in the strength and coherence of their respective organizations; and, indeed, only under such conditions can scientific management achieve its maximum of efficiency. Further, it may be quite confidently asserted, that if under our present industrial order this kind of scientific management or of efficiency engineering cannot thrive, then is that order doomed to be displaced by socialism or some other form of industrial democracy.

The growth of industrial unionism with its emphasis upon direct action, as illustrated in the recent English strikes and the Lawrence strike, indicates that a new era in unionism is beginning. Bitter opposition to organized labor and contemptuous disregard of the demands of employees are strengthening the spirit of solidarity in the ranks of the working class. If it be desirable that a class-conscious and united army of wage-earners be developed, then the bitterest and most uncompromising opponents of organized labor are its friends in disguise; and the union-recognizing employer its dangerous antagonist. But if it be desirable to prevent such a consummation, the wise and conservative entrepreneur of today will recognize organized labor and accept the collective bargain.

In fixing upon the remuneration to be given to the wage-earner in a factory where scientific management is utilized, two points must be determined: the day wage and the amount or rate of the premium or bonus. In either case it is possible to utilize the collective bargain. The premium rate as well as the day wage can undoubtedly be fixed by means of the collective bargain. Scientific management can therefore utilize the collective bargain; it is not restricted to the individual bargain. And it is not clear that the wage-earner need oppose. Although under the premium plan, all workers in a given class would not receive the same weekly wage, yet the premium rate could be adjusted by agreement between the employer and the officers of the union. And the rate also could be so adjusted as to militate against over-driving.[1] The spokesmen of organized labor inform the general public that the union demands a minimum wage, not a uniform wage. But a reasonable premium plan would offer a minimum wage with an opportunity to receive a bonus for efficiency. This would not necessarily militate against organized labor unless a flat rate of

[1] This statement betrays a misunderstanding of the nature of a task. See the article, "The Relation of Scientific Management to the Wage Problem," page 706. — ED.

wages within a given class of workers is essential to the maintenance of union solidarity.

In conclusion, it may be pointed out that the success of collective bargaining which has been asserted to be an essential element in successful efficiency engineering in turn depends upon the solution of the basic problem: What is a fair wage? Or, more specifically, the question may be formulated in the following manner: What is a fair wage in an epoch when competition is being displaced as an effective force in the industrial world? Or, one further step may be taken: Is there a concept of a fair wage which can be made acceptable to both employer and employees? Concretely and specifically, the question may be stated after this fashion: Can a scientific basis be found for the determination of a satisfactory time base and for a satisfactory premium rate for the various progressive wage systems which are being introduced by efficiency engineers? The familiar theories of wages such as the wage-fund theory, the residual theory, and the marginal-productivity theory are all grounded upon the fundamental postulate of free competition. But today monopoly, special privileges, and economic friction play such important rôles in the economic sphere that none of these theories throws much light upon the actual wage question. Indeed, no inconsiderable portion of the recent theorizing as to the rights of labor and of capital is futile because it proceeds on the theory that free competition exists. To work out the hypothetical course of a projectile moving in a vacuum is important; but in order to determine its actual trajectory such studies must be supplemented. In like manner, a theory of wages applicable in a hypothetical state of free competition is desirable; but it also should be supplemented by a thorough study of the effect of economic friction and monopoly.

And, lastly, it may not be irrelevant to inquire: Can scientific management reach a high level of efficiency while approximately one-half of the adult wage-earners of the nation are receiving not more than $500 per year? But students of workingmen's budgets seem to agree that in order to support a normal family in a decent manner an income of $750 to $900 per year is required.

Does not the efficient working-out of a plan of scientific management require the efficiency engineer to go outside the shop in which the workers are employed? Does it not require a study of the conditions surrounding the home life and the recreations of the wage-earner, such as food, housing, amusements, and the like?[1] In building the Panama Canal, it was found necessary to devote much attention to the sanitary conditions within the Canal Zone. This work was carried out as an essential part of the work of building the canal; it was an integral part of scientific management and of good business policy as applied to that great undertaking. Surely the same principles apply to the management of any large business within the borders of the nation.

In brief, these are the conclusions reached: (1) Up to the present, efficiency engineering has been a one-sided matter. (2) If any high degree of success is to be attained the coöperation of the men with the management must be secured. (3) Such coöperation can be secured only by utilizing the collective bargain and by admitting in some measure the representatives of the workers into the councils of the management. (4) And, still further, the success of collective bargaining depends, in the long run, upon finding some mutually acceptable basis for a fair wage.

[1] This fact is fully recognized by practitioners of scientific management; but they also recognize the possibilities of danger and of the accusation of unreasonable interference, if any considerable effort is made to control the food, housing, and amusements of the workers. — Ed.

ANOTHER SIDE OF EFFICIENCY ENGINEERING

By DEXTER S. KIMBALL

PROFESSOR OF MACHINE DESIGN AND CONSTRUCTION, SIBLEY COLLEGE, CORNELL UNIVERSITY

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In these days when hurry and speed are the keynote of industry it would seem to be almost sacreligious, or at least a mark of ignorance, to raise one's voice even in doubt, to say nothing of protest, against any ways or means for increasing production. Yet I cannot but think that only certain aspects of some of the new methods of increasing production are being presented and that those aspects, which are so alluring, entirely overshadow certain others and hence do not give a true perspective of what the net results will be. Now I may be entirely mistaken in my point of view. If so I shall be glad to be corrected and will no doubt find many who will be glad to correct me.

In the outset I wish to state that I believe firmly in modern methods of production and appreciate fully what increased productive power by means of machinery and improved methods has done for our civilization. I believe we should welcome and encourage any and all new discoveries in machinery or methods which will enable us to still further increase our capacity in this direction and gladly accord the honors due to those who have been and now are leaders in this work. No sane man questions the *net* results to humanity of improved modern methods as far as they have affected physical and mental well-being. No one who knows much about manufacturing doubts that many of the methods now being advocated in many quarters under the name of " Efficiency Engineering " will still further multiply the fruits of human effort. The questions which I wish to raise concern the *expediency* of certain methods of applying them and the social and economical effects which are claimed for their application.

The mental and physical welfare of the individual members of any form of organized society are dependent largely upon three factors, namely: —

(1) The natural resources at the command of the community.

(2) The tools and methods of production which are available to develop these resources.

(3) The knowledge and organization whereby the fruits of labor may be fairly and equally distributed.

In the early and simple forms of organized society where resources were ample but tools of production primitive, the third factor came very nearly being realized in full; but as society became more and more complex it became increasingly difficult for the producer to enforce his demands and secure the full return for the service which he had rendered to society. The introduction of machine processes and the tremendous extension of division of labor, intensifying as they have the complexity of our social organization, have still further intensified this difficulty. The effect is greatest where the skill or intelligence of the worker is least. Experience shows that the rate of pay for industrial workers has not increased in proportion to the increase in productive capacity; he would indeed be a bold man who would contend that in our organization today with its immense burden of high financiers, grafters, drones and incompetents, the producing classes, including employer and employee, are receiving full return for the services which they render.

Many civilizations have possessed immense natural resources, and the modern nations possess tools of production such as the world has never seen; but only in the simplest forms of organization has equitable distribution of the products of labor been achieved; all experience goes to show that *increased productive capacity* does not *necessarily* mean increased revenue to the producer; but on the contrary may, if he is not alive to his own interest, mean an actual decrease. We read of few nations who have starved to death for lack of tools or methods of production, but the highway of history is paved with the bones of civilizations which came to grief on the rocks of unfair distribution. Many of the existing modern nations still carry dreadful scars received in bloody revolutions which had their genesis in this, the greatest of problems of organized society, while many more tremble on the brink of similar disasters.

PRINCIPLES OF THE NEW INDUSTRIAL EFFICIENCY

With these things in mind let us examine the principles of the new industrial efficiency as laid down by its leading exponents.[1]

No one can reasonably doubt that the extension of these methods in greater detail will, in general, give increased production, because they have been applied already on a very large scale with great success. And there can be little doubt but what these methods will come into common use and their field be extended more and more as they are more fully understood. Labor-saving machinery and processes always, eventually, come into common use no matter what the opposition to their adoption may be. In the long run it would seem that humanity as a whole benefits from their adoption. It may be noted in passing that the effect of new labor-saving processes and methods is very similar to that of labor-saving machines, namely, to put actual production in the hands of inferior classes of men under the direction of a few more highly skilled or more intelligent leaders. This tends to further extend the principle of division of labor and to disintegrate what are commonly known as trades into fragmentary portions where each worker performs only a small part of what was formerly the work of one man.

Now in the methods under discussion where refined measurements are made of the physical and mental abilities of men it puts into the hands of the employer a more powerful *selective* agency than he has hitherto possessed. If this selective power be used solely for the purpose of *sorting* men so as to eliminate the indolent and those who are clearly unfit for the work in hand there can be no objection raised to them from the humane standpoint. If, however, they are used to *eliminate* all but the very best workers their effect will be disastrous both from the humane and from the economic standpoint until an entire readjustment of the field has taken place. There are at present more men than positions. Any scheme which tends to still further concentrate labor in the hands of a few can hardly be desirable; and in the hands of grasping employers such a result is possible. What is

[1] Mr. Kimball here recites briefly the four Taylor "principles."

wanted is a scheme whereby *every* man can be worked up to his full efficiency whether his output be as great as his neighbor's or not. Economically there can be nothing gained by concentrating labor in the hands of a few picked men if they must support indirectly a large number of idle or poorly paid men. Efficiency is, after all, only a relative term and it is far better that all men be producing up to their capacity than that all the production be by the relatively more efficient. We are as much in need of men who can organize industries and lead the army of producers as we are in need of more refined methods of production.

Some Claims of the Advocates of the New Methods

These new methods then, in so far as we have discussed them, are means of increasing man's productive power and fall, therefore, under the second item of the classification made in the first part of this paper. To what extent will they affect the third item, namely, equitable distribution of the products of labor? The advocates of these new methods make such claims as the following: —

"The great increase in wages which accompanies this type of management will largely eliminate the wage question as a source of dispute."

"The one cure, the only one for the condition that confronts us, is to increase the efficiency of the producer."

"The low cost of production which accompanies a doubling of the output will enable the companies who adopt this management, particularly those who adopt it first, to compete far better than they were able before, and this will so enlarge their markets that their men will have almost constant work even in dull times, and that they will earn large profits at all times.

"This means increase in prosperity and diminution in poverty not only for their men, but for the whole community around them," and many other statements, of the same tenor.

That is to say, increased productive power necessarily means increased profits and their resulting comforts to the actual producer; for a diligent search through the literature of efficiency engineering fails to disclose any new principle regarding the distribution of the fruits of labor. True, great stress is laid on the "square deal" and the coöperation of the employer and employee; but these are not peculiar to any system of management.

It is also, of course, true that decreased cost of production always gives the employer an opportunity to pay better wages until his competitors obtain the same methods, when the natural law of competition again comes into effect, and the employer is again confronted with the choice of smaller profits, lower wages or still more refined methods and improved tools.

Parallel between Labor-saving Machinery and Labor-saving Management

The greatest gain in productive ability which the world has ever witnessed came with the introduction of labor-saving machinery. All the possibilities for the physical and mental betterment of humanity offered by the most tremendous gain in productive power mankind has ever witnessed were opened up at that time. The immediate effect of these new methods was to reduce the workers concerned to a state of pauperism and wretchedness which was relieved only by legislation and other reactive measures and not by anything inherent in the new methods.[1] These methods have been improved and added to steadily for over a hundred years and what is the net result? Today the skilled mechanic who can save a competence is a rarity. Instead of the individual independence which every man should be able to acquire, we are talking of governmental and other forms of pensions; in spite of our much vaunted increased educational facilities only 25 per cent of the entire population of this, the most favóred of countries, get the minimum amount of education which is considered necessary to make them intelligent citizens. True, the workman of all kinds has benefited very greatly by the improved methods, and it is also true that he is better clothed,

[1] It is hardly accurate to say that this was the "immediate effect" or that it was due solely to the introduction of "these new methods." The factors referred to were spread over a period of forty to fifty years and were complicated by many other factors, notably the Napoleonic wars. — Ed.

fed, housed, and particularly better educated than formerly; but the fact remains that his progress has not been proportionate to his increased productive capacity.

I am willing to concede, therefore, that these so called new methods will increase production; that in all probability they will, in time, be generally used and that the general effect should benefit humanity; but I see no reason for thinking that they inherently possess any power to change the problem of distribution. It may be that these methods will even make it necessary for the worker to redouble his efforts. Even the most ardent advocates of the new methods are compelled to acknowledge at times the truth of these statements, as for instance, the following:

" Inasmuch as mechanics as a class get little benefit from the development of a better method or a labor-saving process, they are, as a rule, little interested in such improvements."

And again: " If the fruits of scientific management are directed into the proper channels the workingman will get, not only a fair share but a very large share of the additional profit arising from improved industry. In order that the workingman may get this large share of the benefits through higher wages, shorter hours, and better working conditions, the labor unions must participate in fixing those wages, hours and conditions, and in determining the application to the various businesses of the principles of scientific management." And this is the crux of the whole matter. If the fruits of production under methods as they now exist could be more fairly distributed and the wastes due to foolish and oppressive financiering eliminated so that the producing classes, employer and employee alike, would receive what is justly theirs, much of the problem would be solved; if Mr. Taylor or Mr. Gantt, or Mr. Brandeis can only tell us how this can be done, they will do more for humanity, as it exists in organized society, than any one, economist or engineer, who has ever walked this planet, and infinitely more than can be accomplished by the most refined methods of production which they can develop. The great problem which confronts us is not and has not for many years been that of production, but distribution. We can now produce more manufactured goods than we can use, and far more than is needed to make us all comfortable. All the new productive processes possible will throw little light on the problem of why we find in many places, at one time, storehouses filled with raw material, idle factories equipped with the finest tools the world has ever seen and people walking the street without food or clothing, yet willing to work.

The problem is too complex to be solved by the simple expedient of increased production. There still remain the questions of competition, unfair taxation, immigration and a dozen other factors that are not as yet within the control of the employer, be he ever so fair minded, or of the employee, be he ever so strongly organized. I am not so sure but what a small readjustment of some of these would do as much for the workers, both employer and employee, as a large increase of productive power. What we need most is scientific distribution. Fortunate, indeed, will we be if some of the reactive influences now at work on our social and industrial organization will point the way to this much needed readjustment.

THE TAYLOR SYSTEM OF SHOP MANAGEMENT AT THE WATERTOWN ARSENAL

APPENDIX 1 TO REPORT OF THE CHIEF OF ORDNANCE, 1913

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WATERTOWN ARSENAL, June 21, 1913.

Hon. LINDLEY M. GARRISON,[1]
Secretary of War, Washington, D. C.

DEAR SIR; — We, the representatives of the different trade unions employed at this Arsenal in the various departments do hereby request and petition you to abolish the Stop Watch System because of the unfair and unreasonable methods which are described in the following:

This is the machine shop: A third class machinist rated at $2.56 per day, for instance, working on a job; the stop watch premium makes his appearance and makes a time study of operations, etc. He goes back to his desk and juggles figures for a while and he is given a long time and a short time to finish the job. Sometimes he makes the time reasonable and other times, he is a long way off. This third class man may make a premium of 80 cents to $1.00 per day. But it must be borne in mind that he is only capable of running one kind of a machine, whereas a first class man rated at $3.52 per day (this Arsenal is depending on first class work) can operate any machine and this time study or Stop Watch is not put on the job. You can therefore see the unfairness of this premium system towards a first and third class machinist.

Another case is of a man getting $3.52 per day and running a large machine. Where it requires so much time to finish a large piece, he generally has those pieces on premium from 1 to 6 to 18 months, making $26 to $32 per month. Whereas a man going around the shop at the same pay working at different jobs does not get a chance at this class of work or machine, which is absolutely unfair.

[1] Petition of certain of the workmen. — ED.

It also may be seen that a man is working on a lathe, roughing a dozen pieces. He makes a full premium which is equivalent to $1.00 per day above his day's pay. This job very often is taken away and given to another man to finish, which requires closer and accurate work and is subject to inspection. He makes approximately 15 to 60 cents on the same job. The difference between the time study on the roughing and the finishing of the job can be seen is very unreliable.

Several cases in the Blacksmith Shop that does not work satisfactory according to the Stop Watch Premium:

A blacksmith had been working on several forgings and soon after he had started, he was going to be the first victim for the time piece; forging under normal conditions had been completed and the blacksmith's estimated time for this piece of work was 8 hours and 20 minutes. The Stop Watch man made a time study of operations; went away and juggled figures for a while, came back and set the total time for the completion of this piece of work, six hours, which was impossible for him to do.

Another blacksmith had a much more trying period with the Stop Watch Premium System. He was about to start on several forgings and the Stop Watch man appeared to make a time study of the job, to be completed. The blacksmith, evidently, was not accustomed to this way of doing business. He put a piece of steel into the fire until it was hot and then started to forge the piece with his helper. The Stop Watch man told him to put another piece in the fire while working and he positively refused. The foreman and officer in charge of the shop was notified and came to investigate the matter.

The Stop Watch man told the blacksmith there was no need of his being there then. The blacksmith then told him he did not know why he was there, but that he the blacksmith did know the reason of the Stop Watch man being present there. Finally, the blacksmith went out, saying, "No Stop Watch for me, I have always done a day's work for the Government, and always will as long as I work in this Arsenal."

The System in the foundry has not been carried out as promised. In addition to the speeding up of men, there has been a continual cutting in the time of similar articles. It is not a question in the minds of those in charge of what a job is worth, but is based upon the quickest time that one can make and in nearly every case where fault has been found by the workmen in regard to time, he was told that it was the time set and not satisfaction given whatsoever in this department that it is impossible to keep or to get a sufficient number of laborers owing to the abnormal pace which they are expected to go. This department has unanimously petitioned this continuance of a System.

Take a painter's case, for instance; two men taken from the yard laboring gang were placed upon a job painting shot and shell together with all templets and instructions. For doing the work they are rated at $1.84 per day. The Stop Watch Premium was advised, therefore, they received from 60 to 70 cents, added on to their regular day's pay on account of the premium, and one of the regular painters was suspended for lack of work, whereas if this man was given the work through the regular channels, there would be no need of suspension. Whereas a great deal more work would be accomplished by so doing and the other painters would not have to stop their regular work to mix paint for the laboring men from the yard.

The conditions of the Stop Watch Premium in the Carpenter Shop are equal to those in the Machine Department. For instance, a man started to work recently repairing old Shot and Shell Boxes. The work did not require a very skilful man and the Stop Watch was introduced. This man got 60 cents over his day's pay. It must be taken into consideration that there are first class men in this Wood-Working Department such as cabinet makers, pattern makers and wood turners, whereas it may be seen that the third class rated man gets more money than the first class mechanic by this unfair method.

Referring to the laborer in the Yard, for instance, a time study has been made between shops and buildings, it is expected that the man shall make the same time from day to day irrespective of load or the animal, with no allowance for the conditions of the weather whatsoever. Again, if a carload of pig-iron arrives at this Arsenal with approximately 40 ton on board, it is to be unloaded by Stop Watch Premium. For instance, a car with side boards measuring 4 feet high is expected to be unloaded just as quickly as a car with 18 Side Boards, which is utterly impossible. On a recent occasion, a man with a horse and team entered the foundry to clean up waste material such as slag iron and sand which were unfit for use. They usually use an ordinary shovel with a capacity of 21 lbs., which is described in the so-called Taylor Book. He was told by the Stop Watch man to use a scoop shovel which has a capacity of 40 lbs., and the foreman of the Yard arrived on the job and told him it was not fit for any white man to use on that class of work. The team was loaded, however, with the usual shovel and went on its way to the dumping place. The Stop Watch Man told the foreman in a very sarcastic manner that he should not talk that way before the men to him. Whereas it may be seen that his sole object was to push the man to the dead limit simply because he was a laborer, irrespective of the size of the shovel or the nature of the work.

Referring to the accidents: A great many are caused by this continual driving from day to day. It also may be seen that the majority of men are failing in health. Whereas it is absolutely impossible for a man to work and do justice to himself or the work which is required of him on account of the Stop Watch Premium System. More than 75 per cent of accidents has taken place this year than the previous year of which a very careful record has been made from time to time in all departments. It may also be seen that the bad work and rejections are greater than ever before by 100 per cent. Below is a list of the names of the representative mechanics of their respective departments.

Machine Shop	A. J. Coyle
Blacksmith Shop	Matthew T. Glynn
Foundry	Joseph R. Cooney
Pattern	James B. Cunningham
Carpenter	Eugene P. Gingras
Paint	H. A. Gildersleeve
Yard Laboring	Peter Kidbride

Respectfully yours,

MAURICE W. BOWEN
Chairman, Represenative Committee

23 CHARLES STREET, AUBURNDALE, MASS.

WATERTOWN ARSENAL, June 17, 1913.

HON. LINDLEY M. GARRISON,
Secretary of War, Washington, D. C.

DEAR SIR; — We, the undersigned, employees of the Government, representing 349 of a total of 373 hands employed in the various departments as indicated hereon, respectfully petition that the Taylor System, now in operation at this Arsenal, be immediately discontinued for the reasons as hereinafter set forth.

We object to the use of the Stop Watch, as it is used a means of speeding men up to a point beyond their normal capacity. It is humiliating and savors too much of the slave driver.

A comparison of the record of serious accidents occurring in the works since the introduction of the Stop Watch Premium System will convince the most skeptical that it is dangerous to limb and life, and we claim that a large percentage of these accidents are the direct result of the driving system in vogue at this Plant.

We believe that this System, instead of producing what was claimed it would produce, — high wages to employees, with a low cost of production has worked exactly opposite inasmuch as the investigation into the wages paid (outside of premium) will show that there has been no material increase in wages, while the cost of production has been increased to such an extent that large deficits are being reported on nearly every job of any consequence that is done at this Arsenal.

The number of non-productive employees in proportion to the productive employees who are necessary to carry out the details of the System, has been largely responsible in the great increase in overhead expense, which in many cases, has resulted in the Government being unable to compete with outside concerns and has resulted in contracts being placed with outside parties to do work which the Arsenal is equipped to do and which, under normal conditions, could be done at a cost considerably under that charged by the Contractor securing the work. For instance, it has become the practice to let large contracts for manufacturing patterns, which the Arsenal is equipped to manufacture and could manufacture at a figure considerably below that charged by outside concerns; the quality of work being considered were it not burdened by an excessive overhead charge which must be carried to pay an abnormal non-productive force of employees.

We cite the above case to show that there is ground for our belief that the continuance of this System would finally eventuate in closing this Arsenal as a manufacturing Plant.

A large corps of inspectors are kept busy examining and rejecting material, and the number of pieces rejected since the Premium System was inaugurated has increased by a large percentage. The number of parts rejected since the System was installed will run well into the thousands.

The effect of this System here has been to create a feeling of distrust between the employees and the management; it has destroyed every vestige of coöperation between the workmen and the foremen collectively, and has produced a condition of unhappiness throughout the whole works.

For the reasons as stated above as well as many others which we will not trouble with at this time, we respectfully pray that you, as head of the War Department, take such immediate steps as will effectually remove this System from Watertown Arsenal and restore the workmen to a condition similar to that enjoyed by other artisans and laborers in the public service as well as in most private manufacturing plants.

We also respectfully petition that the records as obtained by means of stop watch observation be removed from this Arsenal or destroyed altogether as they do not represent the normal time in which given work should be accomplished, but rather they are the product of the "speed up" System which has resulted in accidents, inferior work and numerous abuses such as no American Citizen should be called upon to endure.

In conclusion let it be understood that the signatures to this petition were not obtained by coercion or unfair means and each individual signing this petition, does so of his own free will and accord.

Respectfully submitted,

Maurice W. Bowen
Chairman Representative Committee

23 Charles St., Auburndale, Mass.

Signed by 51 molders and helpers; 25 pattern makers, carpenters, and painters; 17 blacksmiths and helpers; 53 yard laboring men; 88 machinists and helpers, assembling department; 88 machinists and helpers.

War Department,
Office of the Chief of Ordnance,
Washington, September 6, 1913.

Memorandum for the Secretary of War.

Subject: Petitions of Watertown Arsenal employees against certain features of the Taylor system of shop management.

1. These petitions were referred to this office accompanied by certain questions in regard to the Taylor system of scientific shop management. These questions will be answered in their order.

Question 1. " Exact figures of everything going into the matter of cost. That is, all expenses upon which cost prices should be figured."

Depending upon the use which is to be made of the figures there are three general classes of costs of articles procured for the public service by the Ordnance Department. These can be called —

(*a*) The appropriation cost,

(*b*) The arsenal cost, and

(*c*) The War Department cost.

2. The appropriation cost includes all expenditures made out of the appropriations for procuring the article, either by manufacture or purchase, such as those made for labor, material, civilian superintendence, power, heat, light, clerical work, drafting, current repairs, leaves and holidays, disabilities, etc.

3. The arsenal cost is the appropriation cost with what is known as the " arsenal burden " added. The arsenal burden is composed of items which increase the cost of the article at the establishment where it is procured, but are not paid for from the congressional appropriation which is made directly for procuring the article, such as interest on the value of the plant, depreciation, allowance for fire losses, pay of officers and enlisted men, etc.

4. The War Department cost is the arsenal cost with the addition of the " War Department burden." The War Department

burden comprises the proportion of the expense of maintaining the War Department proper which is rightfully chargeable to the manufacturing operations of the Ordnance Department. It is composed of the proper proportion of items, such as salaries in the office of the Secretary of War and in the various bureaus of the War Department, contingent expenses of the War Department, rent of buildings for the War Department, expenses of the Office of the Chief of Ordnance chargeable to manufacturing operations, pay of retired officers and enlisted men of the Ordnance Department, etc.

5. The appropriation cost is the only one with which these petitions are concerned, since the statements made therein relate to comparative costs of manufacture before and since the introduction at the Watertown Arsenal of the time study and premium features of the Taylor system. The arsenal cost is generally used for the purpose of comparing Government manufacture as carried on by the Ordnance Department with private manufacture. The War Department cost is of importance when there is a question of securing reimbursement of that department for serviceable property disposed of by it in accordance with the methods authorized by law.

Question 2. " The system as now operated."

6. The Taylor system of shop management may be roughly divided into two general parts. The first part relates to the systemization of processes of manufacture, so that these processes shall be carried on in a perfectly orderly manner, with better forethought and provision than has ever before been given them, and with more detailed arrangements concerning their relations to each other. To the natural inquiry as to what there is new in this, since everybody has always been striving for system and order in manufacturing operations, the answer must be made that the amount of attention which is given under Mr. Taylor's method to system, as evidenced by the number of the personnel engaged and the expense involved — that is, by the amount of administrative energy which is devoted to it — is so different from that which has ever anywhere before his time been devoted to systemization as to be absolutely revolutionary.

7. The second part relates to the quantity of output to be obtained from the workman, and the stimulus required to induce him to cheerfully and earnestly and intelligently strive to give the output. This part rests upon the theory that the best and most expeditious way of doing a piece of work is too difficult of ascertainment for the workman who has to do it to have any reasonable chance of arriving at it; and that it must be reached through painstaking study, by methods prescribed by a highly skilled and expensive specialist, utilizing measurements of the time required by the various elements of a job, and a great deal of knowledge such as the workman does not have and cannot be expected to have. There is the further theory that the current rate of wages, as it exists in any manufacturing community, is not that corresponding to the best directed and most earnest efforts of the employees, but is that corresponding to the class of performance in connection with which the rate has grown up, which is very far from being the best reasonably and agreeably attainable. By expensively finding out the best method of doing a given piece of work, and the time in which it can reasonably be done by following this method, and then by making it very well worth the employee's while to approach, within a given interval, this time, or to improve upon it, means are found to improve the individual output, and to improve the compensation which is paid for it, in a manner profitable and satisfactory to both employer and employee.

8. For a comprehensive understanding of the system and its inauguration at the Watertown Arsenal it will be necessary to read Mr. Taylor's careful works upon *Scientific Management*, upon *Shop Management*, and upon *The Art of Cutting Metal*. A highly condensed exposure of the system and of the three years of its operation at the Watertown Arsenal is, however, contained in my annual reports for the fiscal years 1911 and 1912, from which the pages relating to this subject have been extracted and are attached hereto.

9. The second part of the system, relating to time study of a given job and the premium offered for approaching the time thus arrived at, is the part which is objected to in the petitions, being

called in one of them the "stop watch system," because a timepiece is used in studying the various component elements of a job, so as to arrive at a conclusion as to the manner in which the total time may be shortened. The process can be described as follows: A workman being employed upon a job for which it is intended to set a rate, the time study man takes his station near him and, openly and with the full knowledge upon the part of all concerned of what he is about, proceeds to study the job by first dividing it into its different component movements and periods. He then times carefully each one of the movements and periods, usually more than once. From the data thus obtained he works out what he considers the best sequence of movements and periods, making, if possible, certain elements simultaneous which before were successive, and arrives at a complete program for performing the job and at an estimate of the time in which, by attentively following the program, the job should be completed. This time is called the "task time." It must be understood that the management has theretofore had no definite idea as to the time in which the job should be done, or that it was being done unnecessarily slowly. Knowledge has been lacking to permit an idea as to this point to be formed. Also, any unnecessary slowness is likely to have been caused as much by unscientific methods as by lack of diligence on the part of the workman. The whole object is to secure an intelligent idea of the best way to do the work and of the right time for it. Upon these two points all hands have been without reliable information.

10. After the task time has been arrived at; and it must be remembered that no necessity for unpleasant exertion is admitted in fixing the time; some stimulus in the form of increased pay is given to the workman for meeting this time, or for approaching it. The particular scheme of increase is not important, provided always that it gives an adequate reward for good effort. The scheme applied at the Watertown Arsenal is as follows: The workman is informed that his regular pay is not to be affected. He continues to receive that in any event. The task time is then increased by two-thirds, and he is told that for every minute which he saves within this increased time he will be paid, in addi-

tion to his regular pay, for half a minute, at his regular rate. From this it follows that if he completes the job in exactly the task time the increase in his pay will amount to 33⅓ per cent. No limit is placed upon the time in which he can do the work or the extra amount which he can thus earn, and it frequently happens that the task time is bettered, and more than 33⅓ per cent extra is earned.

11. The commanding officer of the Watertown Arsenal makes a report each month of the premiums earned by the employees of that establishment. A copy of his report for the month of May, 1913, is inclosed herewith. It shows that the premiums earned in that month ranged from practically nothing to $31.02, which was made by a man whose day rate was $3.52, whose total day rate pay was $95.04, and whose premium therefore increased his pay by 35.38 per cent. It is the object of the management to have as many men as possible working under the premium system, and effort is made to enable each workman to increase his premiums to the fullest extent. There has been introduced a system of rewarding the foremen by premiums which increase with the proportion of their subordinates who are working upon premium jobs and with the amount of premiums which they earn. So that the foremen are stimulated to assign as many men as possible to jobs on which they can increase their pay in this way, and to help each one of them to the greatest possible increase. On account of the limited number of time study men, and on account of the nature of the work, it is not possible to give all of the men premium jobs. The report for May shows that, in the foundry during that month, 13 molders out of 13 had such jobs; in the machine shop, 130 machinists out of 166, and 26 machinists' helpers out of 70; among the laborers, 22 out of 45 had such jobs; and in the carpenter shop, 5 carpenters out of 14 worked on premium jobs. The percentage in extra compensation earned by the men on premium jobs, while so working, on an average was, in the foundry, 25.24 per cent; in the machine shop, 24.69 per cent by machinists, and by machinists' helpers, 28.97 per cent; by laborers, 24.06 per cent; by teamsters, 26.35 per cent; by blacksmiths, 39.39 per cent; by blacksmiths' helpers, 39.39 per cent;

and by carpenters, 61.6 per cent. In the foundry 66.95 per cent of the entire working time of the whole number of employees of the class who worked on premium jobs at all was spent on that class of jobs. For the machine shop these figures were 45.65 per cent; for the machinists' helpers, 12.83 per cent; for the laborers, 12.71 per cent; for the teamsters, 26.35 per cent; for the blacksmiths and blacksmiths' helpers, 8.81 per cent; and for the carpenters, 5.38 per cent. It will be seen that there is still much room for including more employees in the number earning premiums, and constant efforts are being made in this direction. The average premium in the month of May, of all the men earning premiums, was $8.96, which was earned by 210 men out of about 600. This average would have been greater if these men had worked on premium jobs all the time, which was not possible.

12. The extracts from my annual reports show that great economy of manufacture, as well as benefit to the workmen, arises from the employment of both general parts of the Taylor system. It has been estimated, from analysis of a large number of jobs, that the increase of output, due to time study and premium payment, in a given time, is about 200 per cent. The analysis was of 39 different jobs, of which records were on hand of the time required to do them, both on the day rate and on the premium system. In four of the cases the jobs, under the two systems, had been done by the same men, and the records showed that the time required by these men, under day work, ranged from one and a half to three and a half times the time in which they did the same jobs under the premium system, with an average of 2.72 times.

13. Perhaps something can be said on both sides of the question of stimulation by high rewards. There are in all walks of life men who wear themselves out in their effort at great accomplishment, and there are more such in a new country, where the rewards are great, than in old countries, where the more settled conditions impose narrower limitations upon what may be accomplished by strenuous and intelligent effort. It is not easy to set a point at which stimulation by high reward should cease. The Taylor system does not attempt to settle the question. But

with the limitation of hours of labor in the Government service, it does not seem to be likely that workmen will be stimulated to efforts injurious to their health by rewards so great that they cannot refrain from overexerting themselves in order to secure them.

14. The question remains to be answered how the process at the Watertown Arsenal differs in kind from the class known as "speeding up," or "sweatshop," or "slave driving" processes, so called. I take it that the essential difference lies in the character of the stimulation which is applied to increase the output. In the reprehensible methods the output of a very rapid workman is taken as the standard, and the rate set is such that this output must be reached in order to make ordinary wages. The task and the compensation are so fixed that, unless the employee puts himself under a great strain all the time he is either discharged or fails to earn a living wage. In other words, the highest possible output is demanded for what is, at best, no more than the current rate of wages. The Taylor system, on the contrary, demands the ordinary output only at the current rate of wages, and, as practised at the Watertown Arsenal, neither effects nor threatens any reduction of the wages in vogue before the introduction of the system. The increased output is accompanied by an increase, and a very substantial increase, in the pay. And no rate is set which requires heart-breaking exertion or exertion of a character which is not agreeable, in order to increase the wages theretofore received. The management spends a great deal of money and a great deal of effort in finding out the best way to do a piece of work. It then offers the workmen an inducement to meet this by giving them the benefit of the time and money spent, in the way of information as to the best way to proceed, in order to enable them to make higher earnings. No discharges have taken place at the Watertown Arsenal because of failure to accomplish work in the time set; and no reduction of pay of any class of the employees had been put into effect since the introduction of the Taylor system. That is, all premiums earned have been over and above the wages which were being received before the system was put into effect. All of the men are informed of the system in practice at the arsenal, and all give their consent to it by being

taken on. The time study and premium features have now been in use for over two years.

15. A great deal has been made of the following statement in one of Mr. Taylor's books:

> When an establishment has reached an advanced stage of organization in many cases a fifth element should be added, namely, the task should be made so difficult that it can only be accomplished by first class men.

This is claimed to be the "speeding up" process, pure and simple. The statement has received some explanation by the following:

> It must be distinctly understood that in referring to the possibilities of a first class man the writer does not mean what he can do when on a spurt or when he is overexerting himself, but what a good man can keep up for a long term of years, without injury to his health, and become happier and thrive under.

The character of the exertion is well covered by the explanation, but perhaps some relief is needed from apprehension in regard to those men who may not be the fastest workmen of their class. Of course common sense prevents the understanding that all men must be thrown out of employment except the very best. The work must be done, and it must be done by such men as are in existence. It is not out of accord with ordinary practice, either under the Taylor system or otherwise, to have one's work done by the best workman that one can get. Harshness of stimulation is avoided by the principle that the task must be such as he who has it to do can "become happier and thrive under." But Mr. Taylor himself has furnished an explanation of what he means by a "first class" man. On pages 1454 *et seq.*, volume 2, of the testimony taken by a committee of the House of Representatives to investigate the use of the Taylor and other systems at Government establishments, he says:

> I have found that an illustration often furnishes the most convincing form of definition. I want therefore to define what I mean by the words "first class" through an illustration. To do so I am going again to use horses as an illustration, because every one of us knows a good deal about the capacity of horses, while there are very few people who have made a sufficient study of men to have the same kind of knowledge about men that we all have about horses. Now, if you have a stable, say, in the city of Washington, containing

300 or 400 horses you will have in that stable a certain number of horses which are intended especially for hauling coal wagons; you will have a certain number of trotting horses; and a certain number of saddle horses — of pleasure horses, and of ponies in that stable.

Now, what I mean by a first class horse to haul a coal wagon is something very simple and plain. We will all agree that a good big dray horse is a "first class" horse to haul a coal wagon (a horse, for instance, of the type of a Percheron). If, however, you live in a small town and have a small stable of horses, in many cases you may not have enough dray horses in your stable to haul your coal wagons, and you will have to use grocer wagon horses and grocery wagons to haul coal in; and yet we all know that a grocery wagon horse is not a "first class" horse for hauling coal, and we all know that a grocery wagon is not a "first class" wagon to carry coal in; but times come when we have to use a second class horse and wagon, although we know that there is something better. It may be necessary even at times to haul coal with a trotting horse, and you may have to put your coal in a buggy under certain circumstances. But we all know that a trotting horse or a grocery horse is not a "first class" horse for hauling coal. In the same way we know that a great big dray horse is not a "first class" horse for hauling a grocery wagon, nor is a grocery wagon horse "first class" for hauling a buggy, and so, right down the line.

Now, what I mean by "first class" men is set before you by what I mean by "first class" horses. I mean that there are big powerful men suited to heavy work, just as the dray horses are suited to the coal wagon, and I would not use a man who would be "first class" for this heavy work to do light work for which he would be second class, and which could be just as well done by a boy who is "first class" for this work, and vice versa.

What I want to make clear is that each type of man is "first class" at some kind of work, and if you will hunt far enough you will find some kind of work that is especially suited to him. But if you insist, as some people in the community are insisting (to use the illustration of horses again), that a task — say, a load of coal — shall be made so light that a pony can haul it, then you are doing a fool thing, for you are substituting a "second class" animal (or man) to do work which manifestly should be done by a "first class" animal (or man). And that is what I mean by the term "first class man."

Now, there is another kind of "second class" horse. We all know him. Among the "first class" big dray horses that are hauling coal wagons you will find a few of them that will balk, a few of them that can haul, but won't haul. You will find a few of these dray horses that are so absolutely lazy that they won't haul coal wagons. And in the same way among every class of workmen we have some balky workmen — I do not mean men who are unable to do the work, but men who, physically well able to work, are simply lazy and who through no amount of teaching and instructing and through no amount of kindly treatment, can be brought into the "first class." That is the man whom I call "second class." They have the physical possibility of being "first class," but they obstinately refuse to be so.

Now, Mr. Chairman, I am ready to answer your question, having clearly in mind that I have these two types of "second class" men in view; the one which is physically able to do the work, but who refuses to do it, and the other who is not physically or mentally fitted to do that particular kind of work, or who has not the mental caliber for this particular job. These are the two types of "second class" man.

The CHAIRMAN. Then how does scientific management propose to take care of the men who are not "first class" men in any particular line of work?

Mr. TAYLOR. I give it up.

The CHAIRMAN. Scientific management has no place for such a man?

Mr. TAYLOR. Scientific management has no place for a bird that can sing and won't sing.

The CHAIRMAN. I am not speaking about birds at all.

Mr. TAYLOR. No man who can work and won't work has any place under scientific management.

The CHAIRMAN. It is not a question of a man who can work and won't work; it is a question of a man who is not "first class" in any particular line; according to your definition.

Mr. TAYLOR. I do not know of any such line or work. For each man some line can be found in which he is "first class." There is work for each type of man, just, for instance, as there is work for the dray horse and work for the trotting horse, and each of these types is first class for his particular kind of work. There is no one kind of work, however, that suits all types of men.

If, under the Taylor system, a man is not earning good premiums, there is an inducement for everybody connected with the management to try to find out the reason. And, if the reason is discovered to be that he is working at a class of employment for which he is not well suited, it becomes everybody's interest to find something for him for which he is well suited and at which he can earn good premiums.

Question 3. "The result of discontinuing the system at present in operation and adopting some other system, and what other system would be recommended if the present system is abandoned."

16. As before stated, the system spoken of is the time study and premium feature of the Taylor system. The result of discontinuing the premium feature would bring all of the employees back to the state of day work system of payment, under which they were working before the introduction of premiums, and, as a matter of course, the output would fall back to that which pre-

viously obtained. That is, the wages of the workmen now earning premiums would be reduced by amounts running up to 35.38 per cent, and averaging about 20 per cent; and the output of these workmen would be reduced about 60 per cent; this without shortening the hours of labor or improving conditions of work. The immediate reduction of the wages of those workmen who are engaged in repetition work could be avoided by substituting for the premium system of payment a piece work system, such as has been for many years satisfactorily used at various other arsenals. So far as these jobs are concerned there would be little to choose between the premium and the piece work system of payment. But there is little repetition work at the Watertown Arsenal, and the repetition jobs now in progress would soon run out. When an attempt is made to set a rate for a new job of repetition work there is always an embarrassing lack of information upon which to base the proper rate. Usually a tentative rate is set, and when this is found unsatisfactory, either to the management or the workmen, as is generally the case, it is changed, to the intense dissatisfaction of either one or the other. Cutting of rates, to meet what has been regarded as unjustifiable wages, has been a fruitful source of dissatisfaction with the piece work system, and has resulted finally, often times, in a limitation of output, holding back both production and compensation. When repetition work of some classes has lasted a long time it sometimes has been found possible to secure a satisfactory and reasonable adjustment of the rate; but even under such conditions the work has proceeded a long time without the advantage, to the management and to the workmen, which would result from an intelligent time study by a skilled specialist, with the object of determining the best program. The repetition jobs at the Watertown Arsenal are too short to permit the use of a try-out method of rate setting, and it is therefore probable that when the work had so changed as to prevent the use of the information which has already been gathered, the abolition of time studies would prevent the formation of new programs and the setting of rates on new jobs, and the work would revert ultimately to the day wage conditions.

Question 4. " Specific facts with respect to all other allegations in these papers."

17. The papers consist of two petitions from workmen at the Watertown Arsenal; one dated June 21, 1913, and signed by names claimed to be those of a representative committee, and one dated June 17, 1913, signed by something over 300 employees. The petitions are fastened together, with the petition dated June 21 preceding. Taking the statements in this petition in order, and numbering them in accordance with the red ink numbers which have been placed on the margin of the petition, they are met as follows:

Complaint No. 1. — This complaint is that a low class machinist is given opportunity of earning from 80 cents to $1 a day by making a good output. There is no claim made that the work is beyond the capacity of the low grade machinist, and it appears to be held that the work ought to be given to a higher grade machinist, whether with or without opportunity to earn a premium is not clear, but from the statement " this time study or stop watch is not put on the job," it may be inferred that the claim is that a high grade man should do the work and that he also should be allowed to earn the premium. On the ground that the reply is obvious none will be made to the claim that a higher-grade man than is necessary should be put on the work; but a reply is needed to the inference that highly paid machinists are not allowed to earn premiums.

A partial reply is found in complaint No. 2, where it is alleged that one high grade machinist makes a premium while another does not, and a conclusive reply is found in the inclosed statement of premiums earned during the month of May, 1913, from which it appears that premiums, and very substantial ones, were, during that month, made by 1 machinist of the $3.76 per day grade, by 8 of the $3.52 grade, by 33 of the $3.28 grade, and by 58 of the $3.04 grade; while they were earned by only 33 of the $2.80 grade, and 7 of the $2.56 grade. It is true, however, that some of the highest-paid machinists, to whom the most difficult jobs must be assigned, do not earn premiums on these jobs, for the reason that, not being intended to be repeated, they are not such as time study can be made upon and a rate for them set. Continued effort is made to so distribute the work that all machinists may have a chance at premium jobs, and when this cannot be done and a low grade man is earning more, through a larger output, than a higher grade man whose output cannot be measured, it is no more than the case which is common in industrial work, of a piece worker with no claim to skill in more than a special and narrow line, who, by special industry, is earning more than a man of much more general skill not on piece work. In either case no one is hurt, and some are benefited.

Complaint No. 2. — This is a complaint that one of the high grade machinists is making a premium while another does not have the chance. It is answered above by the statement that this cannot always be prevented, but that every possible effort is made to distribute the premium jobs so that all may have a chance at them. The extent to which this effort has been successful in the machine shop is evidenced by the fact that, for the months of April, May, and June last, the amount of work under the premium system was 36 per cent of all the work done in that shop, including both machinists and helpers, and in the month of May the premium work was 45.65 per cent of all the work done by all machinists.

Complaint No. 3. — This is a complaint that rates are so set that machinist doing the rough part makes a higher premium than the more highly skilled man doing the finishing part of the same job. No evidence is given in support of this allegation, and its general truth is denied. The rates are so set that it ought to be possible for any workman of any grade to make, without disagreeable effort, 33⅓ per cent more than his day rating, whatever the day rate may be. The day rate is, of course, determined by the class in which the man's skill causes him to be graded. Very conclusive evidence that the allegation is unfounded is contained in the statement made above as to the relative number of men of the different grades who made premiums during the month of May.

Complaint No. 4. — This is a complaint that a blacksmith estimated that it would require 8 hours and 20 minutes to do a certain piece of work, while the time study man placed the time at 6 hours, which is claimed to have been impossible to meet. Taking this complaint just as it stands it appears that since the task time was 6 hours, the time within which premium would commence to be earned would be two-thirds greater, or 10 hours. A blacksmith doing the work in 8 hours and 20 minutes would be paid for one-half of the 1 hour and 40 minutes which he would come within the premium time; that is, he would be paid at his regular rate for 50 minutes of time, which for an ordinary blacksmith would amount to 34 cents. It is shown, therefore, that on his own estimate, the blacksmith would have made about 34 cents a day extra.

In this connection the following example under the premium system is of interest: Time study was made of a job of forging 40 friction bands, after the forging had progressed through several bands. As a result of the study a rate was set requiring the pieces to be forged in 2 hours and 27 minutes each as task time, in order to earn a premium of 33⅓ per cent, or about $1.09 per day. The blacksmith completed the remaining pieces, 33, in an average time of 2 hours and 12.4 minutes each, thereby earning premium of $1.39 per day, more than 33⅓ per cent. For the bands which he had forged before the time study was made he had taken 6 hours and 41 minutes each.

Complaint No. 5. — This seems to be a complaint that, in making time study of a job of forging some crosshead pawls for a disappearing gun carriage, the time study man had endeavored to have the work proceed so that a piece would be in the forge being heated while another piece was being forged; to which the smith objected. In the actual event the point was not insisted upon at the time the study was made, but in fixing the task time the ground was taken that this simultaneous work should be done, that is, a piece should be heated while another was being forged. On this assumption the task time was fixed at 1 hour and 50 minutes, corresponding to a 33⅓ per cent premium. The smith thereupon actually did the work in an average time of 1 hour and 49.5 minutes each, thus earning just over the full premium.

Complaint No. 6. — This is a general complaint of speeding up in the foundry, it being charged that there has been a continual cutting in the time allowed for molding similar articles. When the premium system of payment was first started in the foundry no time studies of molding operations had been made, and as it was desired to give both the workmen and the Government the benefit of the increased production due to the stimulation of premiums as quickly as possible, existing records of time in doing jobs under the day work system were utilized as a basis for setting rates. As was expected, and announced beforehand, many of these rates permitted the earning of abnormal premiums, and some of them did not permit earning sufficient premiums. In the cases where the premiums were too low the rates were adjusted so as to allow higher ones to be earned; but where the premiums attainable were too high the rates for these articles were not changed, and were never thereafter changed; but in setting rates later on very similar articles the experience of the previous rates was utilized so as to permit the average workman to earn the designed premium of 33⅓ per cent. An examination of the inclosed statement of premiums earned in the month of May will show that the average premium earned in the foundry was 25.24 per cent, while the satisfactory fact is also shown that over 66 per cent of all the molder's work done was on a premium basis. These figures are conclusive in showing that the molders in the foundry have had a fortunate experience.

In regard to the charge that it has been impossible to keep or to get a sufficient number of laborers in the foundry owing to the abnormal pace at which they are expected to go, it is sufficient to state that during the fiscal year ended June 30, 1913, only two molders were separated from the service for any cause, one having been furloughed and the other having resigned.

Complaint No. 7. — This is a complaint that the work of painting shot and shell is given to selected men from the laboring gang, at $1.84 per day, with the opportunity of earning premiums said to range from 60 to 70 cents, instead of being given to regular painters, with the result that, in one case at least, a regular painter was laid off for lack of work. Here, again, no charge is made that the laboring men were not capable of doing the work. As a matter of fact, they were capable of doing it, and did it very satisfactorily, since it was exceedingly simple work, requiring no special skill. The regular painters were used for the more appropriate work of mixing the paint and making preparation for the lower grade men. Actually, much of the work required of the laborers was handling the projectiles, which is rough work for which they are better suited than are painters.

Complaint No. 8. — This is another complaint that a man of no great skill was set at doing rather rough work, repairing old shot-and-shell boxes in this case, instead of giving it to a high-grade man. The obvious advisability of giving this kind of work to the class of man that it is stated to have been given to needs no insistence; the fair treatment of the man who did the work is evidenced from the statement in the complaint that he made 60 cents over his day's pay. That the low class man by the methods used was enabled to make as high pay as do cabinet-makers, pattern makers, and wood turners may be a reason why efforts should be continued to get these last classes of skilled woodworkers under the premium system, but it is not a reason for discontinuing the advantage accorded the less skilled woodworker. It has not thus far been found practicable at the Watertown Arsenal to apply time study and premium system of payment to the high grade woodworkers, but efforts to this end are continuing. That is, the management is trying to extend the benefits of the system to those who are not now enjoying them, and is not contemplating withdrawing them from the ones who now have them.

Complaint No. 9. — This is a complaint that the laboring work of carting must be performed without allowance for the day, load, or animal. The carting about the establishment has been put under the premium system and the load is carefully taken into consideration; but no allowance is made for the weather. That the system does not operate unfairly is shown by the fact that in the month of May laborers working on premium jobs earned 24 per cent over and above their pay of $1.84 for the time while they were so working.

Complaint No. 10. — This is a complaint that no allowance is made for the height of the sideboards in the time set for unloading a car of pig-iron. This refinement has not yet been gone into as the cars in which pig-iron is received have usually sideboards of 3 feet or under. Time studies of unloading ordinary pig-iron have not been made at the Watertown Arsenal, but those used in setting rates have been accumulated elsewhere by the time study expert employed at the arsenal. In 13 instances reported there was only 1 in which a considerable premium, 30 per cent in that instance, was earned. The question as to whether any very great efforts to earn premiums were made is raised by the very different lengths of time required to do apparently similar amounts of work. The subject needs more attention at the arsenal and will receive it.

Complaint No. 11. — This is a complaint that the stop watch man endeavored to prescribe the use of shovels of 40 pounds capacity instead of shovels of 21 pounds capacity in cleaning up waste material about the foundry. The point in this case is that the time study man was trying to obtain some experimental information in regard to the use of a 40 pound shovel, and had no intention of continuing the use of this shovel for ordinary work. It appears that he did not insist upon the use of the larger shovel, and that the work went on with the smaller one. The matter is a very unimportant one; but it may be stated that on more than one occasion men have been noticed to be voluntarily using 40 pound shovels in the work referred to.

Complaint No. 12. — This is a complaint that a large increase in the number of accidents is caused by the driving system. Careful record of all accidents is kept at the arsenal. Most of the accidents occur in the machine shop. During the fiscal year ended June 30, 1912, the total number injured in this shop was 34, of which 5, or 14.7 per cent, were working on premium at the time. During the fiscal year ended June 30, 1913, 57 persons were injured in the machine shop, of which 13, or 22.8 per cent, were premium workers. During these two years the number of workmen employed in the machine shop remained about the same, but the amount of premium work increased nearly four-fold. That is, while the amount of premium work increased about 300 per cent, the percentage of accidents to premium workers increased only 8.1. During the nine months from October to June, 1913, 33 machinists were injured, 10 of whom, or approximately 30 per cent, were premium workers. During this same period 44.8 per cent of the work in the machine shop was premium work. It thus appears that the percentage of accidents among the premium workers was less than the percentage of premium work; that is, that the greater proportion of accidents during these nine months occurred among the day workers. These figures are a conclusive refutation of the charge.

It is true that the number of accidents has increased during comparatively recent times. This increase is coincident with the better understanding of the disability act, by reason of which the employees now receive compensation for absence on account of injury, which was formerly denied them.

Complaint No. 13. — This is a complaint that the majority of the men are failing in health. This is distinctly not true. There is no evidence of it, and no complaint of it. A number of men questioned on the subject denied it, no man being found who claimed or admitted that his health had been injuriously affected; and no man has personally claimed that he has been overworked. In regard to the possibility of overwork, it is at least extremely improbable. In machine work particularly, where, as stated before, most of the premium jobs are found, the machinist usually stands for a considerable time looking on while the machine is doing the work. Such a job can be divided into machine time and handling time, and the machine time can be subdivided into that in which the feed is by hand and that in which the feed is by power. It is during the time that power feed is operating that the machinists simply stand and watch the work. Ten jobs, taken at random, have been examined and the following have been found to be the percentage which the power feed time, that is the resting time, is of the whole time required for the job: Job No. 1, 5.75 per cent; job No. 2, 68 per cent; job No. 3, 40 per cent; job No. 4, 58 per cent; job No. 5, 35 per cent;

job No. 6, 46 per cent; job No. 7, 78 per cent; job No. 8, 71 per cent; job No. 9, 80 per cent; and job No. 10, 54 per cent. Of course, during the power feed time the machinist has to fix his attention upon his work; but it is not strained attention, and is not of a wearing character. These figures, coupled with the facts of moderate working hours, frequent holidays, and generally good working conditions, show the practical impossibility, in the general case, of overworking a machinist.

Complaint No. 14. — This is a complaint that the number of rejections for bad work is greater than ever before, by at least 100 per cent. The inspection service has been improved under the Taylor system, and the number of inspectors increased. Formerly it was customary to inspect only the finished pieces, and the inspectors examined only such operations as the foremen called upon them to inspect. Under the better organization of the present system inspections are prescribed in the planning room and many more operations are inspected; with the result that the standard of work is being gradually raised, and that it is much easier than formerly to fix the responsibility for spoiled work, which was then shared indefinitely by the workmen, the foreman, and the inspector. An examination of the rejection reports does not indicate that there is a greater amount of spoiled work by the premium workers than by the day workers. It is also shown that the amount of spoiled work at the Watertown Arsenal is not greater than that of other establishments engaged in work of similar character, and is not inordinate. The economy of its production also indicates that fact.

18. In the petition of June 17, 1913, I have numbered the complaints, as in the previous petition, and will speak of them in order:

Complaint No. 1. — This is a general complaint that the time study system is used as a means of speeding men up abnormally, that it is humiliating and savors of the slave driver. The fact of speeding up men abnormally has been denied, and there ought to be nothing humiliating to an honest workman in an effort to arrive, by careful study, at a measure of the time required to do a given piece of work, in order to set for it a rate which is just, and at the same time enables the workman to make higher pay than ever before.

Time studies are not required for every job, nor more than once upon the same job; that is, they are comparatively infrequent. During the two years in which the process has been in operation at the Watertown Arsenal, 149 men out of about 600 have had time studies made of work which they were performing. Many of these men had only one time study made of their work during the two years, and the maximum number which was made of the work of any one man was 11, and this occurred in the case of 4 men only. The average number was about three, which would mean one in about eight months. As the premium work increased, however, during the latter part of the two years, the average interval during the latter part would be correspondingly shorter.

Complaint No. 2. — This complaint charges the premium system with an increase of accidents and has been answered with reference to the first petition.

Complaint No. 3. — This complaint is a statement that the system has not produced the high wages promised. The complaint is that there has been no increase of wages except through premiums paid. As the only increase promised by the system is through premiums, the complaint falls to the ground. Rates of wages, as is well known, are determined by the wages paid for work of like character in the vicinity; premiums are paid as percentages on those rates. Nothing else has ever been promised, and in this respect the promise has been amply fulfilled.

The statement that the cost of production has been increased to such an extent that large deficits are being reported is the exact contrary of the fact, and in that it is made without knowledge is reckless.

Complaint No. 4. — The substance of this charge is the same as that mentioned above — increased cost of production, and an illustration is given of orders placed with outside parties for patterns which could have been made at the arsenal. When orders for patterns have been placed with outside parties it has been because there were rush orders for them, which otherwise would have required an increase of the pattern making force, which would have been only temporary. It is considered undesirable to frequently increase and reduce the force in any department, and to be detrimental to the interests of the workmen. It is true that in many of these cases, if not all of them the estimate for the manufacture of the patterns at the arsenal was greater than the price for which the patterns were purchased. This is not as it should be, and it may perhaps be explained by the fact that it has not yet been found practicable to apply the Taylor system of shop management to the pattern shop. The statement that the overhead charges due to the system are responsible for the expense therefore falls to the ground, and the strong presumption is raised that an improvement in costs would be effected by applying to the pattern shop some of the features of the system which have been found so effective in other parts of the establishment. This charge as to the cost of patterns instead of being an arraignment of the Taylor system really constitutes an arraignment of its absence.

Complaint No. 5. — This complaint concerns the number of inspections and the rejections for spoiled work, which have been dealt with above.

Complaint No. 6. — This is a statement to the effect that the system is bound to destroy good feeling between the workmen and the management. All the evidence except that of these petitions, is directly to the contrary. There is a cheerful and cordial coöperation between all parts of the establishment and of the individuals employed in it, which is markedly better than that which was apparent before the introduction of the system. The occasions on which men have to be admonished for various reasons have diminished and the coöperative efforts in pushing work along have increased, as was to have been expected when it was made to the interest of everybody to push it along.

19. So much for the specific allegations contained in the petitions. In all cases they show the complaints of injury to be without foundation, and in many cases they show that the complaint of too much premium system is really a complaint of too little of it, in that the point complained of is that somebody is

given a chance at the premiums while another is not. As frequently stated in the course of this paper, efforts are made to increase the amount of premium work, and the success attained is evidenced by the fact that the amount of premium work during the fiscal year ended June 30, 1913, was about four times that of the preceding fiscal year. In the 17 months ended May 31, 1913, the amount of money paid out in premiums, over and above the regular wages, was $22,257.82.

20. In the face of the demonstrated advantage of the premium system to a considerable percentage of the workmen, accompanied by no compulsion to undue or disagreeable exertion and of its disadvantage to none, the question remains as to why there should come in a numerously signed petition for the abolition of the system. The statement advanced of reasons for granting the petitioners' requests are shown to have no basis in fact, in that no injustice or real hardship exists. If the reasons given for the requests are the real ones it ought therefore to be supposed that the objections would disappear upon the showing that their foundation is in error. I think the question is partially answered by the statement that in many instances the petitions do not represent the real sentiment of the persons whose names are attached to them. Upon the receipt of the petitions they were sent to the Watertown Arsenal for certain information, and there a number of the employees were examined individually as to their views. Some stated that they liked the system and had refused to sign the petitions. Several stated that they did not wish to sign, but had done so under compulsion. Also it was discovered that the facts alleged in the petitions were not asserted by a considerable number of the alleged signers, since many signatures were obtained without showing the matter subscribed, to which the signatures were afterwards copied — the signers knowing only that they were opposing the Taylor system. As soon as it became known about the establishment that employees were being individually interviewed a telegram charging intimidation was sent to the local Member of Congress, and at the same time the answers received commenced to take on a uniform tone of opposition to the system. Nevertheless it must be stated that

some of the workmen, including men who were earning good premiums, declared voluntarily their opposition to the system.

21. I think the petitions are due both to the coercion and the teachings of labor organizations. The coercion comes from the opposition which organized labor has always shown to the increase of the productivity of the individual, which it has fought in all the forms in which it has made its appearance, from the time of the introduction of the power loom. The fact that increased individual production redounds ultimately to the advantage of the working classes, as well as to that of everybody else has been powerless to produce a change of attitude in this respect. In the ordinary case this is perhaps explicable by the fact that, while the ultimate advantage is demonstrated, the immediate effect is disastrous to some of the individuals involved, while an immediate remedy for the disaster has not been provided. In the instance of increased productivity at the Watertown Arsenal, however, there has been no immediate disadvantage to any class, since the substantial increase in the wages paid out has not been accompanied by any diminution of the working force.

22. From interviews with the employees I am of the opinion that the teaching of the unions at the Watertown Arsenal is that, if the men will join in the expulsion of the premium system, the political power of the unions will be sufficient and will be used to secure the same increase of pay as is had under the premium system, without the necessity of working for it. This, of course, could not be accomplished without the abandonment of the rule of the department that the wages paid at an arsenal shall be the same as those of the vicinity for work of like character. Careful examination upon this point is periodically made, and it is a fact that at the present time the wages at the Watertown Arsenal are slightly above those paid in the vicinity. Evidence as to the effect of the comparison is always welcome from the representatives of the workmen and readjustment is willingly made when occasion for it is shown.

23. The subject of the discontinuance of the system through legislative action has been up in both Houses of Congress, in which resolutions forbidding it have been introduced and have

been favorably acted upon by the committees to which they were referred. So far as I know the committees have not taken evidence upon the subject matter of the resolutions; no one has been summoned from this department, which is the only Government organization which has introduced the system in its entirety. Pursuant to a resolution of the House of Representatives, a committee of that body investigated the Taylor and the other systems of shop management and their application to Government work in 1911–12, and the committees reporting upon the propositions above mentioned to abolish the system made use of the report of the investigating committee, notwithstanding the fact that this report recommended that there should be no legislation upon the subject at the time. The report of the investigating committee, however, did not make a statement of what it had found at the Watertown Arsenal as a result of its investigation, but mentioned in a condemnation a number of reprehensible practices which it did not find and did not say that it had found at that establishment. It is impossible to find in the report of the committee a statement of the general conditions under the system and of conclusions in regard thereto; these must be sought in reading through the three volumes of evidence taken and printed. I think it would not be difficult for you to reach a conclusion which would be satisfactory to yourself through an examination which you would have the time to make, and I entertain no doubt that, if permitted to handle the matter at the arsenal, without legislative directions, I could continue its operations satisfactorily, since the leaders of disturbance could not hold the men in opposition to the manifest advantages of which they have had experience. But danger lies in congressional action, under pressure from outside the arsenal, and for the purpose of satisfying Congress and the country at large as to the advantage or disadvantage, both to the Government and to the employees, of the features complained of as in operation, I think that an investigation should be made by an authoritative body in which the country could have confidence, which should take the time necessary for the purpose, and would render a report embodying its findings as to the facts and conditions and its conclusions thereon, with its recommendations; which could be relied upon for the government of their action by those in authority who are called upon to take action in the premises and who, of course, have not the time to look thoroughly into the matter for themselves. Such a body I believe to be the Industrial Commission appointed by the President pursuant to the act approved August 23, 1912, entitled "An act to create a commission on industrial relations." I do not believe that there is any more worthy subject for the investigation of this commission than the one of modern scientific management in industrial works, of which they have now an illustration in four years' operation at a Government establishment conducted openly, under public laws and regulations, and operated with solicitude for the welfare of its employees and without profit.

24. The numerous documents containing the information from which this memorandum has been compiled are on file in this office and available for examination, but are withheld in order to diminish the size of this already bulky communication.

Respectfully,

WILLIAM CROZIER,
Brigadier General, Chief of Ordnance.

[Extract from the Report of the Chief of Ordnance, 1911.]

SCIENTIFIC MANAGEMENT

About three years ago the department began to devote attention to the subject of scientific management as applied to its manufacturing operations. Previously to the last fiscal year the subject has been considered more as an experimental detail of shop management, but it has now assumed sufficient importance to justify a reference to it in this report.

It is unnecessary here to attempt any detailed description of the principles of scientific management or the particular application of those principles which constitutes the Taylor System, since both have been the subject of extensive discussion in the public prints and have been very fully described in various treatises. It may be said, however, that the principles are no new

discovery, nor are they claimed to be such by the advocates, and that the many details have been the subject of special and laborious attention for many years. One of the basic ideas is the application of educated and scientifically trained intelligence to those operations of manufacture which were formerly considered either as of too small importance to attract such attention or as belonging entirely to the practice of a trade, and were therefore left to the judgment or choice of those immediately and practically connected with the operations; that is the workmen and foremen. The employees to whom these matters have heretofore been left acquired their skill not from study, but by copying the methods of their predecessors, and are not generally inclined to question the old methods. Besides, the best method of doing certain work is too difficult of ascertainment for the workman to have any chance of success in arriving at it, which has to be done by careful and scientific consideration of a number of variable elements whose successful combination is a matter of high skill and careful observation. An illustration is the process of cutting metal, a particular task involving which is usually given a workman with no other special instructions than that he is to use a particular machine and follow a drawing upon which dimensions and allowed variations therein are specified. The matters which are left to the workman's own determination are the form of cutting tool — which he usually grinds himself — the speed at which he will run the machine, the depth of the cut which he will take in removing the metal which must come off, and the feed which he will set for the travel of the tool along the piece. In determining these matters there should be taken into consideration the character of the metal upon which the work is to be done, the qualities of the steel in the cutting tool, the best length of time for the cutting tool to last without renewal, the strength of the machine, and the capacity of the belting to transmit power to it without slipping. Certain only of these elements can be known to the workman; others are without his ken and have probably been determined without consulting him, as, for instance, the appliances by which the machine is to be given its power and speed, and the specifications for the steel in the cutting

tool; and the best combination so as to secure the completion of the task in the shortest possible time can only be insured by the application of recorded results of long experience and close observation of the art of cutting metals. Efficient work requires that the workman must be given the elements of speed, feed, depth of cut, and a cutting tool by some one who knows what the combination ought to be.

When the claims made by the advocates of scientific management first attracted my attention, the question of the efficiency of existing shop methods was naturally raised in order to estimate the probable value of a change. It is believed that the shop methods in effect at the different arsenals were fully abreast of the best general practice in private industries of the same nature. While, therefore, the general conditions would compare favorably with commercial practice, in those arsenal shops engaged in the manufacture of small arms, ammunition, etc., where the work consists of turning out large quantities of the same pieces, the necessity for closely coördinating the successive operations and for eliminating delays had been more evident than in general machine shop and jobbing work, more study had been given the subject, and as a result the methods there were highly developed. It may be said, in fact, that those shops have had scientific management for years and do not, therefore, appear to afford as wide a field for improvement as might be found in the others. I may also say that one of the earliest publications upon scientific management was a work entitled "The Cost of Manufactures and the Administration of Workshops," by Capt. Henry Metcalfe, an officer of the Ordnance Department, published in 1885. Of Capt. Metcalfe's work Mr. Taylor said, in 1903:

455. Among the many improvements for which the originators will probably never receive the credit which they deserve may be mentioned:

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461. The card system of shop returns invented and introduced as a complete system by Capt. Henry Metcalfe in the Government shops of the Frankford Arsenal. The writer appreciates the difficulty of this undertaking, as he was at the same time engaged in the slow evolution of a similar system in the Midvale Steel Works, which, however, was the result of a gradual development, instead of a complete, well thought out invention, as was that of Capt. Metcalfe.

discovery, nor are they claimed to be such by the advocates, and that the many details have been the subject of special and laborious attention for many years. One of the basic ideas is the application of educated and scientifically trained intelligence to those operations of manufacture which were formerly considered either as of too small importance to attract such attention or as belonging entirely to the practice of a trade, and were therefore left to the judgment or choice of those immediately and practically connected with the operations; that is the workmen and foremen. The employees to whom these matters have heretofore been left acquired their skill not from study, but by copying the methods of their predecessors, and are not generally inclined to question the old methods. Besides, the best method of doing certain work is too difficult of ascertainment for the workman to have any chance of success in arriving at it, which has to be done by careful and scientific consideration of a number of variable elements whose successful combination is a matter of high skill and careful observation. An illustration is the process of cutting metal, a particular task involving which is usually given a workman with no other special instructions than that he is to use a particular machine and follow a drawing upon which dimensions and allowed variations therein are specified. The matters which are left to the workman's own determination are the form of cutting tool — which he usually grinds himself — the speed at which he will run the machine, the depth of the cut which he will take in removing the metal which must come off, and the feed which he will set for the travel of the tool along the piece. In determining these matters there should be taken into consideration the character of the metal upon which the work is to be done, the qualities of the steel in the cutting tool, the best length of time for the cutting tool to last without renewal, the strength of the machine, and the capacity of the belting to transmit power to it without slipping. Certain only of these elements can be known to the workman; others are without his ken and have probably been determined without consulting him, as, for instance, the appliances by which the machine is to be given its power and speed, and the specifications for the steel in the cutting

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When the claims made by the advocates of scientific management first attracted my attention, the question of the efficiency of existing shop methods was naturally raised in order to estimate the probable value of a change. It is believed that the shop methods in effect at the different arsenals were fully abreast of the best general practice in private industries of the same nature. While, therefore, the general conditions would compare favorably with commercial practice, in those arsenal shops engaged in the manufacture of small arms, ammunition, etc., where the work consists of turning out large quantities of the same pieces, the necessity for closely coördinating the successive operations and for eliminating delays had been more evident than in general machine shop and jobbing work, more study had been given the subject, and as a result the methods there were highly developed. It may be said, in fact, that those shops have had scientific management for years and do not, therefore, appear to afford as wide a field for improvement as might be found in the others. I may also say that one of the earliest publications upon scientific management was a work entitled "The Cost of Manufactures and the Administration of Workshops," by Capt. Henry Metcalfe, an officer of the Ordnance Department, published in 1885. Of Capt. Metcalfe's work Mr. Taylor said, in 1903:

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As a result of consideration given the subject the probability that the general machine shop and job work practice might be materially improved by the methods of scientific management seemed great enough to warrant a practical trial. With this object I directed, something over two years ago, the trial at the Watertown Arsenal, Mass., of some of the elementary features of what is known as the Taylor System, with the intention of testing out these features thoroughly and determining their value before proceeding further, and I employed Mr. Carl G. Barth, an expert in shop management recommended to me by Mr. Taylor, to assist us in effecting their introduction.

Mr. Barth's principal service has been the systemization of the general processes of manufacture. Under his guidance we have systematized the method of putting work into the shops, so that orders for manufacture now go from the office to the shops with a much more complete arrangement and supply than formerly of drawings, specifications, lists of parts, bills of material, and orders relating to particular parts of the structure to be produced, so that the foremen are relieved from much of the semi-clerical and other office work which they used to have to do, and for which they are not well qualified and cannot attend to without a neglect of other more appropriate duties. We have systematized the work of planning the course of component parts of the structures to be manufactured through the shops of the arsenal, so that this course shall be regular and orderly, and the work shall at no time be held through the lack of some component which is not at hand when needed, and that no wasteful effects shall arise through congestion of work at particular machines, or the idleness of other machines or workmen, while waiting for the assignment of operations which should have been planned for them in advance. For this purpose there has been installed a planning room, equipped with personnel and appliances, for the regular production of what might be called the time-tables of the thousands of pieces which must travel through the pattern shop, the foundry, the forge shop, the machine shop, and the erecting shop on their way from the stage of raw material to that of finished product, without collisions, or unnecessary delays. We have systematized the issue of material for manufacture from the storehouses to the shops, and have placed the task of estimating the amount of material required among the duties of persons other than those who are to make use of the material in manufacture, so as to reduce the likelihood of over-estimates, to insure the possession of the material at the time when it is needed, prevent the disappearance of material while awaiting use and the duplication of issues, and to insure the return to the storehouse of surplus material, with the result of a useful reduction of the amount of material issued, and supposedly used, for particular fabrications. We have systematized the care of material in store and the accountability for it, so as to insure more frequent and accurate check of the material on hand with the clerical statement of what ought to be on hand. We have also systematized the methods of caring for machines and tools so as to preserve their efficiency; for example, the proper maintenance of the condition and tightness of the extensive system of belting, and the systematic tempering, and grinding of cutting tools; and we have made such improvements in the efficiency of certain machines as to greatly increase their output. As an example of the last-mentioned item of improvement, we made such changes in the cutters and speeds of a certain gear-cutting machine as to increase its daily output nearly threefold, and this at a time when it was operating in accordance with general practice and to the satisfaction of the skilled workman who was employed at it.

The practical effect of these methods at the Watertown Arsenal has been a material reduction in the cost of general manufacture at that place. The most important manufactures at the Watertown Arsenal are seacoast gun carriages, which are large structures, with hundreds of parts, requiring many months for their completion. It is therefore difficult to give at this time many examples of the decrease of cost of production due to the improvements which have thus far been made, but the following are illustrative: Five different orders, each for 40 sets of parts for the alteration of 12 inch mortar carriages have been given in comparatively recent years. The first two orders were executed before the introduction of the improvements very summarily and partially described herein. The average cost per set of these two orders was $1,536.73. The third order was carried through after some little progress had been made in the new methods, and the cost per set under it was $1,120.32. The last two orders had the benefit of most of the improvements which have thus far been introduced, and under these the cost per set was $988.36. Another example is found in the case of 6 inch disappearing gun carriages. Under an order for three carriages which was executed under the old system the cost of each carriage was $24,618.31. Under the new system the cost of each carriage, under an order for two, was $18,103.13. This comparison is, however, not quite accurate, since the first order had to stand the cost of the patterns, which the last order got the benefit of. This cost would, however, not have been nearly sufficient to overcome the difference in price. In the case of the parts for the mortar carriages, the direct labor cost per set was reduced from $411 for the first order of 40 to $275 for the last order, and that of the indirect labor and other shop expenses was reduced from $358 to $332. In the case of the 6 inch disappearing gun carriages the cost of the direct labor was reduced from $10,239 to $6,949, and that of the indirect labor and other shop expenses from $10,263 to $8,956. This satisfactory result has been attained without affecting the pay of the employees or requiring special exertion by them. The previous practice at the Watertown Arsenal was the same as that still followed in practically all machine shops the management of which has not yet appreciated the wastage that a scientific study of the usual practice is claimed to reveal. The principal elements of this wastage include failure to appreciate and to utilize the full and efficient power of machine tools, lack of planning by which machines are frequently without work, the employment of skilled workmen instead of cheaper help to bring work to machines or to procure and grind their cutting tools, etc. By the establishment of specified feeds and cuts the work done by the machines is increased, and by regulating the flow of work so that it shall be even and continuous, and employing laborers and messengers to supply the work and tools to the skilled workmen, the latter are able to devote the time and labor which they previously expended in other ways to work proper for their grade. Mr. Barth entered upon his employment on June 14, 1909, since which date he has given in the 2 years and 3½ months intervening till September 30, 1911, 156 days of service to the arsenal, at a total cost, including his expenses, of $8,808.30.

In view of the successful results obtained at the Watertown Arsenal, in December last I decided to assemble at that arsenal a board, which included the commanding officers of the principal manufacturing arsenals, for the purpose of studying the shop methods which had there been put in practice and of determining the extent to which these methods were suitable for other arsenals.

The board of officers made a thorough study of the Watertown methods and recommended the adoption of those methods for similar work at other manufacturing arsenals, with such changes in details as local conditions seemed to require. In accordance with this recommendation preliminary steps toward introducing the methods, in so far as they are applicable, have been taken at several other arsenals. Due, it is believed, to an erroneous conception of the purposes which it is intended to accomplish by these methods, the employees at one of the other arsenals to which the changes are to be applied have protested against the installation. They have been assured that this department does not contemplate the introduction of any system, or any feature of a system, which is oppressive or unjust. As stated above, the features which have been in effect at the Watertown Arsenal for about two years, and which are all which it is intended to introduce at the other arsenals at the present time, do not affect the wages to be paid to employees or the exertions to be made by them.

The employees have been fully informed as to my intentions in this matter. The explanation given them should suffice to allay any apprehension that may have been aroused by a misunderstanding of the matter, and induce them to await the result of the practical trial of the methods in question, with confidence that their proper interests are not endangered.

In addition to the study of methods, scientific management usually includes some plan for demonstrating to the workman that he can increase his production without unduly exerting him self, and for stimulating him to do so by offering him increased pay for such increase in output. The advocates of the Taylor System claim with great positiveness that the features of that system which do affect the employees' pay, if applied, will result in further very marked economies to the Government, accompanied by increased pay and conditions generally satisfactory to the employees. These claims they base upon the result of actual experience in shops in which the system has been put in operation. The confirmation of the claims as to the advantages of the features first installed, which the practical test at Watertown afforded, lends such force to these further claims that, in the absence of any positive evidence to the contrary, I do not think they can be disregarded by an administrative officer honestly desirous of serving the interests of the Government. Briefly stated these features contemplate offering additional pay to workmen for work performed in the manner and sequence selected from the results of careful study, and completed within the time which that study indicates as sufficient for the purpose. The saving in time results, aside from any increased efficiency of machines, chiefly from the effect of the instructions given the workmen, by which their effort is more advantageously applied, and will involve no exhausting exertion on their part, nor such as should be disagreeable. If the work is not performed within this given time, the workman receives his regular daily pay; never less than his regular pay. The proposition is simply that if he follows his instructions and by so doing saves time, his pay will increase in proportion to the time saved. For example, a workman has been doing a piece of work in 190 minutes. After painstaking study of the job and of all the means of saving time the man is carefully instructed as to these means, and is told that for every minute saved, within say 120 minutes, he will be paid for half a minute at his regular rate, in addition to his regular daily pay; and that it is thought that he can do the work in 72 minutes, for which time the increase over his regular pay will amount to 33⅓ per cent. The real point in the matter, however, is the determination, by a method of scientific common sense, of the time within which the work can and should be done, and the particular method of compensation as a stimulus for meeting this time is not important.

An application of the method described to the first employee of the Watertown Arsenal was made in May last. The circumstances are worth examining somewhat in detail, as they are illustrative of what might, at least, be accomplished by the general use of the method. The case was that of a machinist cutting gear wheels on a gear-cutting machine. It must be remembered that all the preliminary means of improving the machine had already been resorted to. It had been standardized and speeded up and, although not a new machine, it was in as good condition as it could be for getting the best output. The man employed at it, a capable workman, well disposed to turning out a good day's work, had already cut a number of the gears, so that his ordinary rate of production was known. A careful time study had been made, and an instruction card issued to him in accordance with the methods of the Taylor system. The following figures are given as illustrating the change of output: The time which the man had occupied in cutting a gear was 329 minutes; as the result of the time study he had been told that he would be paid at his regular rate for a half minute for every minute under 300 minutes within which he would cut a gear, and that the results of the time study showed that he should cut them in 180 minutes each, in which case his premium would be 33⅓ per cent over his day rate, $3.28, which he was assured he was going to get in any event. No limit was placed upon the amount which he could earn by cutting the gears in still less time than 180 minutes each. Under these conditions the man went at the work and cut 10 gears, all that were left to be cut, in 220 minutes each, thus increasing his pay about 18 per cent over his day rate. This appears to have been a result worth attaining, and was reached, not only by stimulating the man and giving him instructions, but also by affording him all the facilities for doing the work which a careful study made had shown might be given him with advantage to the Government. The magnitude of the achievement does not yet appear in its entirety. Of the 329 minutes which had been previously taken in cutting a gear, 152 minutes was been favorably acted upon by the committees to which they were referred. So far as I know the committees have not taken evidence upon the subject matter of the resolutions; no one has been summoned from this department, which is the only Government organization which has introduced the system in its entirety. Pursuant to a resolution of the House of Representatives, a committee of that body investigated the Taylor and the other systems of shop management and their application to Government work in 1911–12, and the committees reporting upon the propositions above mentioned to abolish the system made use of the report of the investigating committee, notwithstanding the fact that this report recommended that there should be no legislation upon the subject at the time. The report of the investigating committee, however, did not make a statement of what it had found at the Watertown Arsenal as a result of its investigation, but mentioned in a condemnation a number of reprehensible practices which it did not find and did not say that it had found at that establishment. It is impossible to find in the report of the committee a statement of the general conditions under the system and of conclusions in regard thereto; these must be sought in reading through the three volumes of evidence taken and printed. I think it would not be difficult for you to reach a conclusion which would be satisfactory to yourself through an examination which you would have the time to make, and I entertain no doubt that, if permitted to handle the matter at the arsenal, without legislative directions, I could continue its operations satisfactorily, since the leaders of disturbance could not hold the men in opposition to the manifest advantages of which they have had experience. But danger lies in congressional action, under pressure from outside the arsenal, and for the purpose of satisfying Congress and the country at large as to the advantage or disadvantage, both to the Government and to the employees, of the features complained of as in operation, I think that an investigation should be made by an authoritative body in which the country could have confidence, which should take the time necessary for the purpose, and would render a report embodying its findings as to the facts and conditions and its conclusions thereon, with its recommendations; which could be relied upon for the government of their action by those in authority who are called upon to take action in the premises and who, of course, have not the time to look thoroughly into the matter for themselves. Such a body I believe to be the Industrial Commission appointed by the President pursuant to the act approved August 23, 1912, entitled "An act to create a commission on industrial relations." I do not believe that there is any more worthy subject for the investigation of this commission than the one of modern scientific management in industrial works, of which they have now an illustration in four years' operation at a Government establishment conducted openly, under public laws and regulations, and operated with solicitude for the welfare of its employees and without profit.

24. The numerous documents containing the information from which this memorandum has been compiled are on file in this office and available for examination, but are withheld in order to diminish the size of this already bulky communication.

Respectfully,

William Crozier,
Brigadier General, Chief of Ordnance.

[Extract from the Report of the Chief of Ordnance, 1911.]

Scientific Management

About three years ago the department began to devote attention to the subject of scientific management as applied to its manufacturing operations. Previously to the last fiscal year the subject has been considered more as an experimental detail of shop management, but it has now assumed sufficient importance to justify a reference to it in this report.

It is unnecessary here to attempt any detailed description of the principles of scientific management or the particular application of those principles which constitutes the Taylor System, since both have been the subject of extensive discussion in the public prints and have been very fully described in various treatises. It may be said, however, that the principles are no new

discovery, nor are they claimed to be such by the advocates, and that the many details have been the subject of special and laborious attention for many years. One of the basic ideas is the application of educated and scientifically trained intelligence to those operations of manufacture which were formerly considered either as of too small importance to attract such attention or as belonging entirely to the practice of a trade, and were therefore left to the judgment or choice of those immediately and practically connected with the operations; that is the workmen and foremen. The employees to whom these matters have heretofore been left acquired their skill not from study, but by copying the methods of their predecessors, and are not generally inclined to question the old methods. Besides, the best method of doing certain work is too difficult of ascertainment for the workman to have any chance of success in arriving at it, which has to be done by careful and scientific consideration of a number of variable elements whose successful combination is a matter of high skill and careful observation. An illustration is the process of cutting metal, a particular task involving which is usually given a workman with no other special instructions than that he is to use a particular machine and follow a drawing upon which dimensions and allowed variations therein are specified. The matters which are left to the workman's own determination are the form of cutting tool — which he usually grinds himself — the speed at which he will run the machine, the depth of the cut which he will take in removing the metal which must come off, and the feed which he will set for the travel of the tool along the piece. In determining these matters there should be taken into consideration the character of the metal upon which the work is to be done, the qualities of the steel in the cutting tool, the best length of time for the cutting tool to last without renewal, the strength of the machine, and the capacity of the belting to transmit power to it without slipping. Certain only of these elements can be known to the workman; others are without his ken and have probably been determined without consulting him, as, for instance, the appliances by which the machine is to be given its power and speed, and the specifications for the steel in the cutting

tool; and the best combination so as to secure the completion of the task in the shortest possible time can only be insured by the application of recorded results of long experience and close observation of the art of cutting metals. Efficient work requires that the workman must be given the elements of speed, feed, depth of cut, and a cutting tool by some one who knows what the combination ought to be.

When the claims made by the advocates of scientific management first attracted my attention, the question of the efficiency of existing shop methods was naturally raised in order to estimate the probable value of a change. It is believed that the shop methods in effect at the different arsenals were fully abreast of the best general practice in private industries of the same nature. While, therefore, the general conditions would compare favorably with commercial practice, in those arsenal shops engaged in the manufacture of small arms, ammunition, etc., where the work consists of turning out large quantities of the same pieces, the necessity for closely coördinating the successive operations and for eliminating delays had been more evident than in general machine shop and jobbing work, more study had been given the subject, and as a result the methods there were highly developed. It may be said, in fact, that those shops have had scientific management for years and do not, therefore, appear to afford as wide a field for improvement as might be found in the others. I may also say that one of the earliest publications upon scientific management was a work entitled "The Cost of Manufactures and the Administration of Workshops," by Capt. Henry Metcalfe, an officer of the Ordnance Department, published in 1885. Of Capt. Metcalfe's work Mr. Taylor said, in 1903:

> 455. Among the many improvements for which the originators will probably never receive the credit which they deserve may be mentioned:
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> * * * * * * *
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> 461. The card system of shop returns invented and introduced as a complete system by Capt. Henry Metcalfe in the Government shops of the Frankford Arsenal. The writer appreciates the difficulty of this undertaking, as he was at the same time engaged in the slow evolution of a similar system in the Midvale Steel Works, which, however, was the result of a gradual development, instead of a complete, well thought out invention, as was that of Capt. Metcalfe.

As a result of consideration given the subject the probability that the general machine shop and job work practice might be materially improved by the methods of scientific management seemed great enough to warrant a practical trial. With this object I directed, something over two years ago, the trial at the Watertown Arsenal, Mass., of some of the elementary features of what is known as the Taylor System, with the intention of testing out these features thoroughly and determining their value before proceeding further, and I employed Mr. Carl G. Barth, an expert in shop management recommended to me by Mr. Taylor, to assist us in effecting their introduction.

Mr. Barth's principal service has been the systemization of the general processes of manufacture. Under his guidance we have systematized the method of putting work into the shops, so that orders for manufacture now go from the office to the shops with a much more complete arrangement and supply than formerly of drawings, specifications, lists of parts, bills of material, and orders relating to particular parts of the structure to be produced, so that the foremen are relieved from much of the semi-clerical and other office work which they used to have to do, and for which they are not well qualified and cannot attend to without a neglect of other more appropriate duties. We have systematized the work of planning the course of component parts of the structures to be manufactured through the shops of the arsenal, so that this course shall be regular and orderly, and the work shall at no time be held through the lack of some component which is not at hand when needed, and that no wasteful effects shall arise through congestion of work at particular machines, or the idleness of other machines or workmen, while waiting for the assignment of operations which should have been planned for them in advance. For this purpose there has been installed a planning room, equipped with personnel and appliances, for the regular production of what might be called the time-tables of the thousands of pieces which must travel through the pattern shop, the foundry, the forge shop, the machine shop, and the erecting shop on their way from the stage of raw material to that of finished product, without collisions, or unnecessary delays. We have systematized the issue of material for manufacture from the storehouses to the shops, and have placed the task of estimating the amount of material required among the duties of persons other than those who are to make use of the material in manufacture, so as to reduce the likelihood of over-estimates, to insure the possession of the material at the time when it is needed, prevent the disappearance of material while awaiting use and the duplication of issues, and to insure the return to the storehouse of surplus material, with the result of a useful reduction of the amount of material issued, and supposedly used, for particular fabrications. We have systematized the care of material in store and the accountability for it, so as to insure more frequent and accurate check of the material on hand with the clerical statement of what ought to be on hand. We have also systematized the methods of caring for machines and tools so as to preserve their efficiency; for example, the proper maintenance of the condition and tightness of the extensive system of belting, and the systematic tempering, and grinding of cutting tools; and we have made such improvements in the efficiency of certain machines as to greatly increase their output. As an example of the last-mentioned item of improvement, we made such changes in the cutters and speeds of a certain gear-cutting machine as to increase its daily output nearly threefold, and this at a time when it was operating in accordance with general practice and to the satisfaction of the skilled workman who was employed at it.

The practical effect of these methods at the Watertown Arsenal has been a material reduction in the cost of general manufacture at that place. The most important manufactures at the Watertown Arsenal are seacoast gun carriages, which are large structures, with hundreds of parts, requiring many months for their completion. It is therefore difficult to give at this time many examples of the decrease of cost of production due to the improvements which have thus far been made, but the following are illustrative: Five different orders, each for 40 sets of parts for the alteration of 12 inch mortar carriages have been given in comparatively recent years. The first two orders were executed before the introduction of the improvements very summarily and partially

As an example of what is shown by this department's record of employment; the gear-cutting machinist whose experience has been described above has been a regular employee of the department for a number of years. During the fiscal year ended June 30 last, in which the experience described occurred, he had been given, as usual, leave of absence with pay for 13¾ days' annual leave, 13 Saturday half-holidays, and 7 full holidays, making 27¼ days in all, for which he received $83.56, without rendering any service. For the service which he did render during the year he received $899.65. The amount which he received for no service therefore was a little over 9¼ per cent of that which he received for his labor; and the labor was rendered at the rate of only eight hours a day. His holiday time he was privileged to use for his own pleasure or profit. In addition he had the stability of the civil-service tenure of office; had an opportunity to take his luncheon in a clean, well-warmed and ventilated and well-kept lunch room, where facilities were supplied for heating coffee, etc.; was able to take a shower bath at the end of his work if he wished to; and enjoyed the assurance that if disabled by his work for over 15 days he would, under the governmental liability act, be paid at his full rate for the time for which his disability should last, up to one year; or that his dependent family would be provided for at such rate in case of his being killed. With this experience I do not believe that, of his own motion, this good man would have become suddenly possessed of the fear that the spirit of his employment by the Government was to be entirely changed and that thenceforth he was to be subjected to an unendurable slave driving process.

The theory under which the trial is being made at the Watertown Arsenal is that the current rate of wages is not a just compensation for the employees' best production, but that it is compensation for the character of production under which the rate has grown up, which is very far from the best. It is believed that better production can be had by proper care upon the part of the management, but that continued high production is impossible without correspondingly high wages. It is also considered that there are differences between men which should be taken account of in their compensation. There is not lacking evidence that these differences are not always relished by labor organizations, and that there is some tendency upon the part of members of these organizations to consider that they should be industrially as well as politically equal; and it may be that this feeling is stronger on the part of employees in a Government establishment, feeling that all men are properly equal before the law, than in private employment. I have not yet reached a conclusion as to the extension to other arsenals of the part of the Taylor system of shop management which directly affects the workmen, and I do not intend to do so in advance of further trial at the Watertown Arsenal; but I am convinced that, either by this system or by some other, it ought to be possible to secure better coöperation of the employees among themselves and between them and the management than has been had in the past. I think it ought to be possible to accomplish this by making it to the interest of as many employees as possible to call attention to any improvement which would increase their productiveness, or to any slackness which diminishes it, and I do not think that the spirit of keenness and forwardness which ought to accompany conditions of this kind would properly be described as one involving spying, or a state in which every man's hand would be against his neighbor, as has been alleged.

As to the effect upon the employment of labor which would be produced if a given amount of work were to be performed by a less number of men than had previously been required for it, it should be borne in mind that at a Government establishment the amount of work is regulated by the capacity of the establishment and the appropriations available. If by means of improved methods this department should be able to diminish the cost of military stores manufactured by it, by reason of the increased efficiency of labor or otherwise, the funds thus saved would not be turned back into the Treasury, but would be used to manufacture additional stores, for which there is much need, requiring the employment of additional labor. This result would be comparable to that obtaining in private manufacture when diminished cost and price increase consumption.

In getting this system going for the last two years or more the commanding officer of the Watertown Arsenal, Lieut. Col. Charles B. Wheeler, and his first assistant, Maj. C. C. Williams, have been called upon for efforts much in excess of those corresponding to ordinary working hours and have exhibited a degree of zeal and intelligence which merits special mention.

[Extract from the Report of the Chief of Ordnance, 1912.]

SCIENTIFIC MANAGEMENT

In my report for the fiscal year ended June 30, 1911, the subject of the application of more scientific management to the plants of the Ordnance Department was discussed at some length, and a detailed statement of the reasons that determined the trial, the extent to which the system had been introduced, the conditions under which it would be retained or extended, and the results already obtained were given.

During the past year the subject has received even greater public attention than before, so that it is deemed proper to describe the progress made and the conditions that have developed since my last annual report in greater detail than would otherwise be considered necessary.

The occurrence of the brief strike among the molders at the Watertown Arsenal, mentioned in my last annual report, was represented by the outside labor interests which had supported the strike and were encouraging opposition to the introduction of scientific management in the plants of this department as indicating the existence of unsatisfactory conditions, due to the use of the particular system of management under trial, known as the Taylor System. The representations made induced the House of Representatives to appoint a special committee to investigate the Taylor and other systems of shop management. While the resolution authorizing the appointment of the committee provided for the investigation of other systems, it specifically named the Taylor System and directed that the applicability of this system to Government works, its effect on the health and pay of the employees, and on wages and labor cost be ascertained. The special committee thus appointed began its labors on October 4, 1911. The members visited the Watertown Arsenal and held hearings there, at Boston, New York, and Washington, covering a period between October 4, 1911, and February 12, 1912. Ample opportunity was afforded to all Government officers and employees, outside labor leaders and workmen, industrial engineers, civilian managers, and generally to any one interested in the subject, to present their views to the committee. In short, the committee went into the subject thoroughly and had presented to it in great detail all the information needed for an exhaustive study and the formation of an authoritative conclusion. The committee made its report to the House on March 9, 1912, and it was unanimous. Inasmuch as the opponents of the Taylor System had virtually concentrated their attack upon the time study and premium features under trial at the Watertown Arsenal, claiming that those features operated against the health and well-being of the employees, it is particularly interesting to note what the committee, as the result of its investigation, had to say upon the points especially affected by those features. Their remarks were as follows:

> Neither the Taylor system, the Emerson system, the Gantt system, the Brombacher system, the Stimpson system, nor any of the systems of so-called scientific management have been in existence long enough for your committee to determine with accuracy their effect on the health and pay of employees and their effect on wages and labor cost. The conclusions we have arrived at are all based upon what we consider to be the logical sequence of the conditions existing or proposed. The selection of any system of shop management for the various Government works must be to a great extent a matter of administration, and your committee does not deem it advisable nor expedient to make any recommendations for legislation upon the subject at this time.

In other words, the committee, properly zealous to protect the well-being of the employees, failed to find any ground in the representations made by the opponents of the system upon which to base condemnation or serious criticism of the methods in effect or contemplated by this department, or any conditions which called for remedial legislation, although it showed its alert interest in the well-being of the workmen by mentioning and condemning many oppressive practices, which it did not find, and did not say it had found, at the arsenals of this department. This result should be sufficient to stay the campaign against the use of the Taylor system by the Government, which, on the part of its opponents, has been principally one of misrepresentation of the purposes sought, and unjustified assertions as to the results which it would produce, at least until bad conditions become a fact instead of a mere prediction. Particularly have these opponents endeavored, by quoting carefully selected and therefore misleading extracts from the writings of its original advocate, to create a popular prejudice against the time study and premium features of this system, alleging that these features are only devices for "speeding up" the workman and reducing him ultimately to the level of a "machine" or "beast of burden." The persistency with which these statements have been circulated, in the face of failure of the committee to discover any facts which justify them, excites more than a suspicion that there is some other reason which animates the opposition than a fear that the employees of the department are going to be overworked. The following instance, which occurred at the Watertown Arsenal, well illustrates the fact that the time study is not an instrument of oppression, but that the determination of the proper quantity of work revealed by its use is advantageous to the workman as well as to the Government, and that the department intends to act justly upon the information thus obtained. After a time study had been made on a piece of work, the workman proceeded to earn a good premium, but upon comparing the cost of the work to the Government before and after the premium system of payment, it was discovered that the cost was greater afterwards than before. That is, there was no saving of time and overhead charges to compensate for the increased amount paid to the workman. The reason was that this was an exceptionally fast and skilful man, and that he had been all along giving an output corresponding to a reasonable task time without getting paid for it. In other words, he was underpaid. The time study disclosed this, and he is now being paid in accordance with his merits.

In spite of the well-grounded conclusion reached by the committee that no legislation is needed at present, interests outside of the Government service have, nevertheless, succeeded in having bills introduced into both Houses of Congress which aim to prohibit the taking of accurate time studies of operations and the payment of premiums, or extra pay, to the workman. The effect of these bills, if enacted into law, would be to deprive the workmen of all material advantages that scientific management offers them. The attitude of the department is that improvement in industrial conditions should benefit both employer and employee. This attitude is clearly evidenced by the record that the department has made in its dealings with its employees and was given positive expression in my testimony before the special committee last January. To prevent any misunderstanding upon this point, it is considered fitting to quote that portion of the hearings which contains the expression referred to:

Mr. Tilson. There is another question I would like to ask in regard to the system. If, after a fair trial of the second part, as we have called it, of this Taylor system, at Watertown Arsenal, it should be found that it does not work satisfactorily to both the Government and the men, after a fair trial, so it could not be claimed on either side that it had not a fair trial, it should be discovered that it could not be installed satisfactorily to the workmen themselves and to the management, do you believe that it would be installed at the other arsenals, regardless of that fact?

Gen. Crozier. No, sir; it would not be my intention to install it at the other arsenals under those circumstances.

Mr. Fitzgerald. Would it mean the elimination of that feature at the Watertown Arsenal?

Gen. Crozier. Yes, sir; it would.

Mr. Fitzgerald. In its entirety?

Gen. Crozier. Of this second part of the system?

Mr. Tilson. Any part which did not work satisfactorily.

Gen. Crozier. I would not permanently continue any system that was the cause of continued discontent.

Mr. Tilson. You regard the workmen at the Watertown Arsenal as fair-minded men — the majority of them — men who as between man and man would wish to be fair. Now, after giving it a fair trial with these men, if it engendered constant strain and you could not make any satisfactory arrangement with this system, would it not discourage it in your eyes?

Gen. Crozier. Yes, sir; it would. After I shall have given it a fair trial, then I shall know everything about it of my own knowledge.

Mr. Fitzgerald. Of course, there are some features that might remain after this second part of the system was presumed to have been abolished, like the time records, for instance. Would workmen be required to still maintain the time as determined by the time study methods of this system?

Gen. Crozier. I think I have covered that when I say that I would not continue anything that produced permanent discontent.

Mr. Tilson. The system or any part of it ?

Gen. Crozier. No, sir.

Mr. Tilson. I just wanted to be sure of what you said, General. I simply wanted it reiterated, that is all.

Gen. Crozier. Anything that produced permanent dissatisfaction and discontent would be given up. We desire to have our relations with the workmen harmonious.

Mr. Tilson. That 's the point.

These expressions should not be misinterpreted. They do not mean that any feature deemed beneficial will be given up immediately upon the request of employees, without investigation of the grounds and reasons for such a request. Before the abandonment of a feature is decided upon it must be demonstrated that those objecting to it have worked under it long enough to understand it thoroughly, that their objections are material and based upon their own experience rather than the suggestions of others, and that they represent in number more than the small discontented element that exists in all industrial organizations.

The time study affords the most accurate measure yet devised for determining the just quantity of work that should be performed without overexertion, and the premium system is one of the means by which this just quantity of work can be adequately paid for. The combination of the two secures increased earnings to the competent workman, without a corresponding decrease to the less competent, a positive and material step forward which it would seem should meet with general approval. The proposed bill, however, takes away this advantage, and requires the workman to continue to labor under the old conditions, the unsatisfactory and inadequate character of which is evidenced by the symptoms of general unrest occurring throughout the industrial world.

The advocates of these bills profess to foresee that the time study and premium features will produce conditions inimical to the workman, and draw a harrowing picture of a future in which the overwrought workman is laboring feverishly to accomplish daily a task beyond his strength in return for a wage no greater, and perhaps less, than he formerly received. The absurdity of the supposition that such a state of affairs in a plant belonging to this Government would be tolerated by the people, or that there is any incentive which would lead sane Government officials to attempt anything of the sort, does not seem to strike these prophets. Neither do they appear to comprehend the fact that the determination of the rate of wages to be paid is a matter wholly independent of any system of management. The Taylor system has no occult power to force workmen to work under unsatisfactory conditions or for an inadequate wage. It does not take away from the workmen any weapon of self-protection which they now possess. Wages are not fixed by a system, but by agreement. Under the Taylor system there is exactly the same opportunity for bargaining, either individually or collectively, exactly the same remedies for oppressive conditions, in short, exactly the same protection for the workmen that there is under any other system — no more and no less. The same forces that operate now to maintain, raise, or depress the rate of wages will operate as effectively under the Taylor system, and these are the only forces that can affect the question. When the time study has revealed more accurately than mere guesswork how much work can properly be done, there still remains the question as to how much shall be paid for that work. The settlement of that question is not determined by the time study, nor by any other feature of the Taylor System. But the result of the time study has furnished the workman with a vastly better ground upon which to bargain about wages than he had when both parties were merely guessing as to the amount of a fair day's work. In the face of the actual results so far obtained, and the unequivocal statements as to the future intention of this department, the effort to protect the workmen from purely visionary dangers by depriving them of a present and very material benefit appears so strained and illogical as to suggest irresistibly either that the real reason for the effort has not been revealed or that those who profess to be so alert in protecting labor are singularly obtuse. Should they be successful in their effort to eliminate the time study and premium features, the workman who has become accustomed to receiving a substantial increase in his pay envelope under the premium system is going to find it difficult to figure out how he has been benefited when that increase is taken away from him and his hours of work are not reduced. I believe that the practical experience of the benefits of the premium system obtained by those who have worked under it during the past year will lead to a saner and more enlightened view of the subject, and develop clearly the fact that there is not, on the part of those who are personally affected, any real wish for the enactment of legislation so evidently opposed to their interests.

To show how directly and materially the premium system, based upon time study, has benefited the workman, I invite attention to the following data as to the number, trade, and grade of the employees who have worked on premium during the past year, and the average monthly percentage of their regular pay represented by the premiums earned. (See tables, pages 795–801.)

The net result of these figures may be more significantly summarized by the statement that 153 men received during the last fiscal year a total of $6,938.43 more than they would have been paid except for the time study and premium features. Had conditions been such that all of these men could have been employed continuously on premium jobs, the premiums earned would constitute an actual increase in their annual pay of 28.59 per cent.

These very substantial increases earned under the premium method, without complaint of undue or disagreeable exertion, can hardly be regarded by any unprejudiced person as other than a distinct improvement in the industrial position of the workmen concerned, who must have been enabled thereby to live better and to obtain for themselves and their families advantages not previously enjoyed. It is difficult to believe that these men and those dependent upon them really favor a legislative prohibition of the premium feature, which would deprive them of their new comforts and compel a return to their former scale of living. I do not believe it, but by evidence gathered on the spot, as well as by the above considerations, am convinced that a free expression of opinion by the employees of the Watertown Arsenal, if it were

PREMIUMS EARNED DURING MAY, 1913

By Molders

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium percent. earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
4	27	..	$3.04	$82.08	$12.41	$94.40	32	39	82	10	39.73
5	27	..	3.28	88.56	4.55	93.11	11	7	70	45	15.71
6	14	3	3.04	43.70	5.62	49.32	14	47	93	50	15.75
7	27	..	3.52	95.04	23.72	118.76	53	54	181	35	29.68
8	27	..	3.52	95.04	13.91	108.95	31	37	128	35	24.58
9	27	..	3.52	95.04	13.46	108.50	30	35	176	35	17.29
10	23	..	3.52	80.96	16.60	97.56	37	44	137	30	27.44
11	27	..	3.28	88.56	17.23	105.79	42	2	163	20	25.73
12	27	..	3.52	95.04	18.66	113.70	42	24	118	45	35.70
15	27	..	3.68	99.36	20.94	120.30	45	32	195	25	23.30
16	27	..	3.04	82.08	11.39	93.47	29	59	142	40	21.01
17	27	..	3.52	95.04	15.11	110.15	34	20	104	25	32.88
18	27	..	3.68	99.36	20.95	120.31	45	33	195	25	23.30
Total	..	..	..	..	194.55	..	452	13	1,791	..	25.54

Premium percentage of shop = $\frac{452 \text{ hrs. } 13 \text{ min.}}{1{,}791 \text{ hrs.}}$ = 25.24 per cent. Hours worked on premium is 66.95 per cent of the entire working time of all employees of the same class.

In Machine Shop

No.	Days	Hours	Day rate	Total pay, day rate	Premium	Total amount paid	Hours	Mins.	Hours	Mins.	Average premium percent. earned
31	27	..	$3.04	$82.08	$1.12	$83.20	2	57	27	25	10.76
33	21	..	3.28	68.88	4.03	72.91	9	50	58	40	16.76
35	24	7	3.04	75.62	8.51	84.13	22	23	135	40	16.49
38	27	..	3.28	88.56	20.85	109.41	50	52	166	10	30.61
39	27	..	3.52	95.04	31.02	126.06	70	30	199	10	35.38
41	27	..	3.28	88.56	21.26	109.82	51	52	158	30	32.72
42	27	..	3.28	88.56	21.38	109.94	52	9	164	5	31.78
43	27	..	3.04	82.08	6.41	88.49	16	52	128	20	13.14
44	15	6	3.04	47.88	6.96	54.84	18	19	67	30	27.13
45	27	..	3.28	88.56	19.44	108.00	47	25	136	35	34.71
46	18	..	3.28	59.04	25.47	84.51	62	7	175	45	35.34
47	27	..	3.28	88.56	21.12	109.68	51	31	184	35	27.91
48	26	4	3.04	80.56	5.09	85.65	13	24	170	30	7.46
49	27	..	3.28	88.56	9.85	98.41	24	2	191	45	12.53
50	27	..	3.52	95.04	29.70	124.74	67	30	193	25	34.89
51	27	..	2.80	75.60	14.13	89.73	40	23	141	35	28.52
52	27	..	3.04	82.08	24.14	106.22	63	32	155	35	40.83
54	27	..	3.28	88.56	14.79	103.35	36	5	132	5	27.31
55	27	..	3.04	82.08	5.96	88.04	15	42	196	25	7.99
56	24	..	3.04	72.96	10.57	83.53	27	40	92	5	30.20
57	27	..	3.28	88.56	1.44	90.00	3	30	15	...	23.33
58	26	4	3.04	80.56	4.87	85.43	12	50	36	...	35.64
59	27	..	3.28	88.56	23.14	111.70	56	27	210	25	26.82
60	27	..	3.28	88.56	6.16	94.72	15	2	39	55	37.66
61	27	..	3.04	82.08	10.35	92.43	27	14	108	45	25.04
62	27	..	2.80	75.60	8.33	83.93	23	49	113	55	20.91
63	26	4¾	3.04	80.84	13.84	94.68	36	26	118	15	30.81
64	26	4	3.52	93.28	6.19	99.47	14	4	130	10	10.80

PREMIUMS EARNED DURING MAY, 1913 — Continued

IN MACHINE SHOP — Continued

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium percent earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
65	27	..	$3.28	$88.56	$8.82	$97.38	21	31	154	10	13.85
67	26	5	3.28	87.33	8.01	95.34	19	32	56	30	34.57
68	27	..	2.56	69.12	.86	69.98	2	42	46	55	5.75
69	26	..	3.28	85.28	22.15	107.43	54	1	226	35	23.85
70	27	..	3.04	82.08	25.62	107.70	67	26	193	15	34.88
71	27	..	3.04	82.08	9.63	91.71	25	21	74	...	34.25
72	27	..	3.04	82.08	8.87	90.95	23	21	310	40	7.51
73	27	..	3.28	88.56	30.22	118.78	73	42	166	20	44.30
75	27	..	3.52	95.04	13.68	108.72	31	5	151	15	20.55
76	26	6	3.04	81.32	13.43	94.75	35	21	176	20	20.04
78	25	1½	3.28	82.61	18.40	101.01	44	53	129	45	34.59
79	26	7	2.80	75.25	4.98	80.23	14	14	80	5	17.17
80	26	7½	2.80	75.42	10.13	85.55	28	56	180	20	16.04
81	23	..	3.04	69.92	15.91	85.83	41	52	137	50	30.37
82	27	..	2.80	75.60	23.89	99.49	68	16	191	25	35.66
83	27	..	3.04	82.08	13.43	95.51	35	21	105	40	33.45
84	26	2	3.04	79.80	25.31	105.11	66	36	194	55	34.16
85	27	..	3.28	88.56	28.25	116.81	68	54	187	5	36.81
86	27	..	3.04	82.08	4.61	86.69	12	8	43	5	28.16
87	27	..	3.04	82.08	3.04	85.12	7	59	58	25	13.46
88	27	..	2.80	75.60	18.29	93.89	52	16	173	35	30.11
89	27	..	3.28	88.56	11.35	99.91	27	41	85	25	32.41
90	25	..	3.28	82.00	12.51	94.51	30	30	310	10	9.85
91	27	..	3.28	88.56	18.03	106.59	43	59	113	35	38.71
92	27	..	3.04	82.08	17.38	99.46	45	44	198	35	23.02
93	25	..	3.04	76.00	18.31	94.31	48	11	169	40	28.98
94	25	1	3.28	82.41	24.21	106.62	59	3	196	20	30.07
95	27	..	3.28	88.56	1.03	89.59	2	30	54	50	4.53
99	26	6	3.28	87.74	4.61	92.35	11	14	65	...	17.28
102	27	..	3.52	95.04	23.05	118.09	52	23	179	5	29.25
103	26	3	2.80	73.85	.73	74.58	2	5	145	25	1.43
105	27	..	2.80	75.60	11.96	87.56	34	11	134	20	25.44
107	26	1½	3.04	79.61	3.49	83.10	9	11	29	5	31.57
108	27	..	3.04	82.08	1.26	83.34	3	19	30	50	10.75
110	26	7½	3.04	81.89	6.14	88.03	16	9	55	30	29.09
111	27	..	3.28	88.56	2.37	90.93	5	47	28	30	20.39
112	26	1½	3.04	79.61	9.91	89.52	26	5	94	20	27.65
115	27	..	3.04	82.08	.22	82.30	...	34	31	15	1.81
116	27	..	3.04	82.08	17.37	99.45	45	42	151	55	30.08
117	27	..	3.04	82.08	5.90	87.98	15	32	101	10	15.35
120	26	2½	3.04	79.99	13.59	93.58	35	45	134	25	26.59
121	5	..	2.80	14.00	...	14.00	...	...	7	30	
122	27	..	2.56	69.12	7.04	76.16	22	...	140	5	12.73
123	27	..	3.52	95.04	20.49	115.53	46	34	159	30	29.18
124	27	..	3.04	82.08	6.64	88.72	17	28	96	55	18.02
125	26	7½	3.52	94.82	5.50	100.32	12	30	126	50	9.85
126	10	..	3.04	30.40	...	30.40	...	...	9	20	
128	27	..	3.28	88.56	6.87	95.43	16	46	78	20	21.40
129	9	..	3.28	29.52	.57	30.09	1	23	15	...	9.22
133	10	..	3.04	30.40	.18	30.98	1	32	6	40	23.20

PREMIUMS EARNED DURING MAY, 1913 — Continued

In Machine Shop — Continued

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium percent. earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
135	25	4½	$3.04	$77.61	$13.71	$91.32	36	4	105	...	34.34
136	27	..	2.80	75.60	.04	75.64	...	7	25	55	.45
137	23	7½	3.04	72.77	13.84	86.61	36	25	131	10	27.76
138	25	..	3.04	76.00	1.74	77.74	4	34	146	15	3.12
139	27	..	3.52	95.04	13.13	108.17	29	51	158	35	18.82
140	25	2½	2.80	70.79	2.57	73.36	7	21	71	15	10.31
141	27	..	3.04	82.08	11.11	93.19	29	14	125	...	23.38
143	26	..	3.04	79.04	11.35	90.39	29	52	92	15	32.37
144	26	7	2.80	75.25	9.69	84.94	27	42	105	5	26.36
145	2	..	2.80	5.60	...	5.60	...	...	3	10	
146	27	..	3.28	88.56	18.96	107.52	46	14	157	...	29.44
148	26	6	3.04	81.32	18.66	99.98	49	6	169	55	28.88
149	25	6	3.04	78.28	...	78.28	...	...	13	10	
151	25	3½	2.80	71.22	13.16	84.38	37	37	141	45	26.53
153	27	..	2.80	75.60	.31	75.91	...	54	50	30	1.51
154	25	6½	3.04	78.47	.86	79.33	2	15	3	45	60.00
155	26	5½	3.04	81.13	1.53	82.66	4	2	18	25	21.90
158	6	..	3.04	18.24	71	18.95	1	52	21	10	8.81
159	27	..	2.56	69.12	22.21	91.33	69	25	198	15	35.01
162	26	5½	2.56	68.32	8.14	76.46	25	26	98	15	25.88
168	27	..	2.80	75.60	5.64	81.24	16	7	76	20	18.45
169	27	..	2.56	69.12	...	69.12	...	...	30	50	
176	27	..	2.80	75.60	4.54	80.14	12	59	95	...	13.66
177	26	5½	2.80	74.72	23.15	97.87	66	8	159	25	41.48
178	27	..	3.04	82.08	.09	82.17	...	14	2	30	9.33
179	27	..	3.28	88.56	9.71	98.27	23	41	147	35	16.04
180	27	..	3.04	82.08	29.58	111.66	77	51	217	30	35.79
182	27	..	3.28	88.56	5.92	94.48	14	27	44	25	32.53
186	26	4	3.04	80.56	19.30	99.86	50	47	166	40	30.47
188	27	..	3.76	101.52	3.51	105.03	7	28	22	35	33.06
191	24	4	2.56	62.72	11.47	74.19	35	50	120	20	29.77
196	27	..	3.28	88.56	19.59	108.15	47	47	235	25	20.29
197	26	4½	2.56	68.00	3.79	71.79	11	51	80	...	14.81
198	27	..	2.80	75.60	4.48	80.08	12	49	71	55	17.82
199	11	5	3.04	35.34	.49	35.83	1	17	44	15	2.90
200	26	4	3.04	80.56	.68	81.24	1	47	5	55	30.14
201	27	..	3.04	82.08	16.68	98.76	43	53	134	25	32.64
202	27	..	2.80	75.60	4.49	80.09	12	50	60	40	21.15
203	27	..	3.04	82.08	4.88	86.96	12	51	39	35	32.46
210	26	7½	3.28	88.35	22.97	111.32	56	1	182	55	30.62
211	26	1	3.04	79.42	18.71	98.13	49	14	185	...	26.61
212	27	..	3.04	82.08	11.05	93.13	29	5	167	5	17.40
215	26	7½	3.04	81.89	2.13	84.02	5	37	19	35	28.68
216	26	7½	2.80	75.42	7.49	82.91	21	24	85	25	25.05
220	26	7½	3.04	81.89	3.97	85.86	10	27	91	35	11.41
222	27	..	3.04	82.08	2.10	84.18	5	31	18	15	20.32
223	26	6½	2.80	75.07	1.57	76.64	4	29	20	...	22.41
224	25	..	3.04	76.00	5.07	81.07	13	20	48	20	27.58
225	27	..	3.28	88.56	12.24	100.80	29	52	120	40	24.75
226	25	7	3.04	78.66	16.65	95.31	43	49	152	25	28.74

PREMIUMS EARNED DURING MAY, 1913 — Continued

IN MACHINE SHOP — Continued

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium per cent earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
227	27	..	$2.80	$75.60	$3.47	$79.07	9	55	34	40	[illegible]
287	25	½	3.04	76.19	26.57	102.76	69	55	192	30	[illegible]
Total	..	..	..	..	1,398.06	..	3,601	8	14,583	35	[illegible]

Premium percentage of shop = $\frac{\text{3,601 hours 8 minutes}}{\text{14,583 hours 35 minutes}}$ = 24.69 per cent. Time worked on premium is 45.65 per cent of the entire working time of all employees of the same class.

BY CRANEMAN

283	28	7	$62 per m.	$59.68	$1.26	$60.94	4	49	14	5	[illegible]

Hours worked on premium is 1.38 per cent of the entire working time of all employees of the same class.

BY CHIPPER

312	27	..	$2.24	$60.48	$0.82	$61.30	2	55	8	...	[illegible]

Hours worked on premium is 3.7 per cent of the entire working time of all employees of the same class.

BY MACHINISTS' HELPERS

42	27	..	$2.80	$75.60	$5.70	$81.30	16	18	58	35	[illegible]
174	27	..	2.40	64.80	1.07	65.87	3	33	48	55	[illegible]
228	27	..	2.00	54.00	3.85	57.85	15	25	46	25	[illegible]
232	27	..	2.00	54.00	7.38	61.38	29	30	177	...	[illegible]
233	27	..	2.24	60.48	6.63	67.11	23	41	68	5	[illegible]
234	27	..	2.40	64.80	9.54	74.34	31	47	82	30	[illegible]
235	27	..	2.40	64.80	3.05	67.85	10	9	60	...	[illegible]
236	27	..	2.00	54.00	3.24	57.24	12	59	40	...	[illegible]
240	25	..	2.00	50.00	3.77	53.77	15	4	56	25	[illegible]
244	27	..	2.00	54.00	3.61	57.61	14	27	44	25	[illegible]
247	26	4	1.84	48.76	.40	49.16	1	44	5	35	[illegible]
252	27	..	2.00	54.00	16.49	70.49	65	59	158	5	[illegible]
258	26	..	1.84	47.84	2.98	50.82	12	59	40	...	[illegible]
260	27	..	1.84	49.68	...	49.68	...	...	29	35	
263	27	..	2.00	54.00	3.70	57.70	14	48	45	30	[illegible]
272	25	4	2.00	51.00	.34	51.34	1	22	12	45	[illegible]
275	27	..	2.00	54.00	8.09	62.09	32	21	120	15	[illegible]
277	26	3	2.00	52.75	3.59	56.34	14	22	40	40	[illegible]
278	26	4	1.84	48.76	1.71	50.47	7	27	22	35	[illegible]
292	27	..	2.24	60.48	8.15	68.63	29	8	114	25	[illegible]
294	25	..	2.00	50.00	4.43	54.43	17	42	55	25	[illegible]
295	26	..	1.84	47.84	1.70	49.54	7	24	21	20	[illegible]
298	27	..	2.00	54.00	9.10	63.10	36	24	96	55	[illegible]
303	25	5	2.00	51.25	9.38	60.63	37	32	154	20	[illegible]

PREMIUMS EARNED DURING MAY, 1913 — Continued

By Machinists' Helpers — Continued

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium percent. earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
309	27	..	$1.84	$49.68	$14.81	$64.49	63	24	184	...	35.00
314	24	7½	1.84	45.88	.44	46.32	1	56	6	25	30.12
Total	..	..	..	..	133.15	..	518	25	1,789	40	28.06

Premium percentage of shop = $\frac{\text{518 hours 25 minutes}}{\text{1,789 hours 40 minutes}}$ = 28.97 per cent. Time worked on premium is 12.83 per cent of the entire working time of all employees of the same class.

By Laborers

54	27	..	$2.24	$60.48	$0.40	$60.97	1	45	5	20	32.81
4	27	..	1.84	49.68	8.94	58.62	38	53	132	...	29.45
5	5	..	1.84	9.20	.22	9.42	...	57	3	40	25.90
7	28	..	2.00	56.00	1.23	57.23	4	55	15	35	31.55
11	28	..	2.00	56.00	.26	56.26	1	2	3	40	28.18
12	17	..	2.00	34.00	.44	34.44	1	46	6	15	28.26
14	25	4	2.00	51.00	11.92	62.92	47	44	140	10	34.05
16	28	..	2.24	62.72	.03	62.75	...	7	1	25	8.23
17	27	..	1.84	49.68	1.19	50.87	5	11	39	35	13.09
18	27	..	2.00	54.00	2.29	56.29	9	10	43	35	21.03
22	27	..	2.00	54.00	5.34	59.34	21	23	45	40	46.82
24	27	4	2.00	55.00	2.33	57.33	9	20	38	45	24.08
26	26	4	1.84	48.76	2.15	50.91	9	22	45	...	20.81
36	27	..	1.84	49.68	.18	49.86	...	48	2	...	40.00
37	26	4	1.84	48.76	6.17	54.93	26	50	100	10	26.78
41	25	..	1.84	46.00	1.95	47.95	8	29	41	15	20.56
43	26	..	1.84	47.84	.18	48.02	...	48	2	...	40.00
44	21	..	1.84	38.64	.48	39.12	2	7	42	5	5.02
48	26	..	1.84	47.84	.71	48.55	3	4	58	45	5.21
52	26	..	1.84	47.84	.05	47.89	...	14	22	45	1.08
54	27	..	1.84	49.68	.06	49.74	...	17	13	...	2.17
58	26	7	1.84	49.45	2.05	51.50	8	52	41	5	21.58
Total	..	..	..	..	48.66	..	203	4	843	45	23.02

Premium percentage of shop = $\frac{\text{203 hours 4 minutes}}{\text{843 hours 45 minutes}}$ = 24.06 per cent. Time worked on premium is 12.71 per cent of the entire working time of all employees of the same class.

By Rigger

13	30	..	[1] $62.00	$62.00	$1.28	$63.28	4	54	15	35	31.44

Hours worked on premium is 6.49 per cent of the entire working time of all employees of the same class.

[1] Per month.

PREMIUMS EARNED DURING MAY, 1913 — Continued

By Fireman

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium per cent. earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
39	30	..	[1] $75.00	$75.00	$1.52	$76.52	4	55	15	35	31.55

Hours worked on premium is 6.49 per cent of the entire working time of all employees of the same class.

By Teamsters

3	27	..	$2.00	$54.00	$7.94	$61.94	31	45	134	...	23.69
8	26	4	2.24	59.36	7.51	66.87	26	51	83	30	32.15
28	27	..	2.00	54.00	6.47	60.47	25	53	83	20	31.06
29	23	..	2.00	46.00	5.49	51.49	21	57	85	35	25.64
30	22	..	2.00	44.00	2.78	46.78	11	8	73	30	15.14
45	27	..	2.00	54.00	9.50	63.50	37	59	130	20	29.14
Total	..	..	..	..	39.69	..	155	33	590	15	26.14

Premium percentage of shop $= \frac{\text{155 hours 33 minutes}}{\text{590 hours 15 minutes}} =$ 26.35 per cent. Time worked on premium is 48.38 per cent of the entire working time of all employees of the same class.

By Blacksmiths

3	27	..	$3.52	$95.04	$14.98	$110.02	34	2	82	5	41.46
6	27	..	3.28	88.56	4.38	92.94	10	41	31	25	34.00
Total	..	..	..	..	19.36	..	44	43	113	30	37.73

Premium percentage of shop $= \frac{\text{44 hours 43 minutes}}{\text{113 hours 30 minutes}} =$ 39.39 per cent. Hours worked on premium is 8.81 per cent of the entire working time of all employees of the same class.

By Blacksmith Helpers

25	26	..	$2.00	$52.00	$8.51	$60.51	34	2	82	5	41.46
29	26	..	2.00	52.00	2.67	54.67	10	41	31	25	34.00
Total	..	..	..	..	11.18	..	44	43	113	30	37.73

Premium percentage of shop $= \frac{\text{44 hours 43 minutes}}{\text{113 hours 30 minutes}} =$ 39.39 per cent. Hours worked on premium is 8.81 per cent of the entire working time of all employees of the same class.

[1] Per month.

PREMIUMS EARNED DURING MAY, 1913 — Continued

BY CARPENTERS

No.	Time		Day rate	Total pay, day rate	Premium	Total amount paid	Hours of premium time paid for		Hours worked on premium		Average premium percent. earned
	Days	Hours					Hours	Mins.	Hours	Mins.	
58	27	..	$3.04	$82.08	$7.92	$90.00	20	51	36	15	57.51
63	27	..	3.04	82.08	13.47	95.55	35	27	53	40	66.05
65	27	..	3.28	88.56	.39	88.95	..	57	2	20	40.71
67	27	..	2.80	75.60	12.44	88.04	35	33	53	45	66.13
68	27	..	3.04	82.08	2.39	84.47	6	17	14	50	42.35
Total	..	..	..	..	36.61	..	99	5	160	50	54.55

Premium percentage of shop = $\frac{\text{99 hours 5 minutes}}{\text{160 hours 50 minutes}}$ = 61.60 per cent. Hours worked on premium is 5.38 per cent of the entire working time of all employees of the same class.

Date	Number of men	Hours worked on premium jobs		Hours of premium time paid for		Premium paid	Regular pay	Per cent of premium
		Hours	Min.	Hours	Min.			
MOLDERS								
July, 1911	..	..	..	..	..	..	..	..
August, 1911	18	796	55	113	7	$46.72	$332.60	14.0
September, 1911	19	1,745	45	450	35	186.46	721.97	25.8
October, 1911	17	1,962	40	439	35	182.35	807.64	22.6
November, 1911	16	1,564	30	389	40	161.58	644.54	25.1
December, 1911	18	2,141	56	478	29	198.74	881.80	22.5
January, 1912	17	2,570	30	692	40	286.88	1,061.11	27.0
February, 1912	19	2,392	..	562	40	183.11	1,037.26	17.6
March, 1912	18	2,175	50	600	59	246.79	917.67	26.9
April, 1912	12	1,644	..	507	..	207.81	674.21	30.8
May, 1912	11	1,490	45	478	41	197.03	614.56	32.1
June, 1912	11	1,298	16	380	53	156.85	533.89	29.4
						$2,054.32	$8,227.25	24.97
MACHINISTS								
July, 1911	4	255	..	59	45	$20.16	$84.46	23.8
August, 1911	8	[1] 830	..	190	45	67.40	[1] 351.08	19.2
September, 1911	10	1,052	39	255	15	92.73	384.96	24.0
October, 1911	15	1,261	28	316	8	115.36	420.89	27.4
November, 1911	20	2,612	5	637	11	235.27	941.21	25.0
December, 1911	30	3,217	45	844	39	314.14	1,166.93	26.9
January, 1912	51	4,766	30	1,329	37	506.64	1,769.78	28.6
February, 1912	52	4,195	30	1,086	20	414.75	1,580.38	26.1
March, 1912	59	5,088	25	1,629	7	613.60	1,898.40	32.3
April, 1912	88	6,350	5	1,980	40	745.08	2,385.41	31.2
May, 1912	94	7,497	55	2,309	11	876.16	2,849.30	30.7
June, 1912	84	7,511	55	2,311	22	882.82	2,868.97	30.7
						$4,884.11	$16,701.77	29.24

[1] One man's time omitted on account of loss of card; time assumed.

possible to receive it, would be strongly in favor of a continuance of the system.

The figures given above show the benefits which accrue to the workman from the Taylor System as applied at the Watertown Arsenal. It is now appropriate to consider what advantages have been secured for the Government. In my last annual report such typical examples of reduced cost of manufacture were given as were available at that time. It must be remembered that the Government lacks the simple measure of economical efficiency which a private concern possesses in its net earnings, and that a convincing and definite comparison can only be had when the same or very similar articles have been manufactured under both new and old conditions. It should not occasion surprise, therefore, that the concrete instances available are not more numerous. But while these instances are not many, they serve to indicate beyond a reasonable doubt that the methods which have been so successful in the cases cited are producing a proportionate success in the work generally. From a comparison of the job cards of about 60 different jobs, each of which was performed under both the old day work and the premium system, it appears that the average rate of production under the premium system is about 2½ times that of day work. Had the same number of men been working on premium work throughout the year as were employed on such work during May and June at the Watertown Arsenal, there would have been a total net saving to the Government of $100,095.80. Inasmuch, however, as the number in the earlier months was much smaller, the amount saved was less, and the saving actually made was $49,102.95, as compared with the amount which had been estimated that the work was going to cost.

Savings from Improved Shop Management and Premium System (except as noted) and Disposition Thereof

The reduced cost of production at the various ordnance establishments, due to the improved methods of manufacture and to the premium system, as previously outlined, will continue to be realized from year to year. These savings were made with practically no reduction of wages of employees; on the contrary, there were a large number of increases in day wages at all the arsenals, and the earnings of those on a piece work or premium basis were increased considerably. These increases, of course, have been deducted from the amount of savings reported below. Due to the existence of these savings for the current fiscal year the estimates for the next fiscal year have been reduced, thus giving the most practical expression to the results obtained. The savings amounted to over $240,000, which was used to increase the amount of work done and material manufactured under the various appropriations from which the savings were made. The estimates for the manufacture of small arms ammunition during the next fiscal year have been reduced by $150,000 below the current appropriations; but for the reduced sum just as much ammunition will be procured as would be possible under the present appropriations at the prices of a year ago. The estimate for the manufacture of small arms is $100,000 less. The number of small arms made will not be as great as under the current appropriation, but it will not be diminished in proportion to the reduction in the estimate.

These figures need little comment, and, taken in connection with those showing the increased earnings of the workmen, furnish a complete explanation and justification of the advocacy of the Taylor system by this department. The workmen have received higher wages, while the net cost of the work has been reduced, an industrial result which both employers and employees are generally desirous of achieving. So far, at least, the advantages anticipated for both the Government and the employees have been realized, and none of the objectionable results so confidently predicted by its opponents have developed. The present situation, therefore, offers every inducement for the continuance of the conservative application of the Taylor system begun by this department, and such extension of the use of those features proved to be beneficial as local conditions shall justify.

Surplus Stock Savings

Inasmuch as scientific management more systematically directs greater attention to all details of manufacturing work than was previously bestowed, its trial by the department led to a closer study, among other objects, of the amount and kind of material that should be kept on hand for manufacturing purposes, with the object of reducing such stock to the lowest limit consistent with efficient and economical operation. The study given this subject resulted in the adoption during the past year of a uniform system for determining the amount of stock to be carried and for providing for its replenishment. The overaccumulation of stock is easily accomplished. Material is prone to be scattered through a manufacturing establishment in unimpressive lots and to rest in out of the way places unobserved. The record of it is buried in the property return, often under a variety of half-known names, not meaning much to the clerks who handle the returns, which for the large arsenals are ponderous volumes discouraging critical examination. A careful determination under a scientific method of the proper quantity of stock to be kept on hand revealed the fact that in the case of many items the quantity had been excessive, and that the stock of those items could be greatly reduced. The process of realizing upon this surplus by using it in current manufacture was at once begun and will be continued until it is all absorbed. It will take several years to accomplish this. During the past year $122,789.61 worth of this surplus has been used. This means that the manufacture of the articles for which the surplus material was used was accomplished by the actual disbursement of $122,789.61 less than would otherwise have been required so that that amount of money was available for additional work.

The surplus stock savings, amounting to $122,789.61, were utilized in manufacturing 2,189 additional infantry rifles and a large amount of small arms ammunition; while $17,585.13 were turned into the Treasury, as the purpose to which this sum was applicable can be covered by other appropriations without increase. Some $17,000 of this saving is still on hand.

Stock Fund not yet Utilized

At the Springfield Armory there is a remaining surplus of $130,313.53 over and above that mentioned above. When future orders are received by the armory for the manufacture of arms report in each case will be promptly made to this office showing the value of the surplus material which can be utilized in such manufacture, and the allotment covering such orders will then be correspondingly reduced. This surplus consists largely of those components of the rifle which require the longest time, in the event of war, for their procurement, as, for instance, gun stock, which should be seasoned for several years prior to use, and steel for the larger parts, as for the barrel and receiver, so that the amount of the saving does not represent a corresponding quantity of material for that number of completed rifles. It will require several years to absorb this surplus, which represents the amount by which the war reserve of material can be reduced by reason of the satisfactory store of finished rifles.

Reports have not yet been received from the other arsenals as to the resulting surpluses that will be available for such use in the stock fund. When such reports shall have been received these surpluses will be similarly utilized.

Recapitulation of Savings

Savings from improved shop management, and premium system	$240,461.93
Savings resulting from the use of surplus stock	122,789.61
Total	$363,251.54

Scrap material was utilized, as usual, in the manufacture of all articles whenever possible. The value of the scrap material so utilized during the year amounts to about $212,000. Under the new stock system this scrap is now taken up at its proper value on the stock fund account. That used in the manufacture of any article is charged against the allotment for its manufacture and credited to the stock fund account. When the stock fund exceeds an authorized maximum the excess is turned back to this office and made available for allotment for additional manufactures.

Cash Rewards for Employees

During the past year the subject of the desirability and justice of securing authority by which employees who were the authors of suggestions that resulted in value improvements or economies in manufacturing processes or plant could be adequately rewarded was taken up and a recommendation submitted to you that an effort be made to obtain the necessary legislative action.

The history of this department contains many instances of employees who have offered suggestions that resulted in material improvements and economies. Under previously existing law there was no suitable way by which the laudable interest of these employees could be properly recognized. This lack of power to reward such suggestions undoubtedly deprived the Government of much advantage that would accrue from the stimulus to the interest in their work that could otherwise be secured, and placed the Government in the unsatisfactory position of appropriating such suggestions and benefiting from them without suitable recognition of the authors. The action recommended met with your approval and the matter was submitted to Congress. The result was the passage of an act, approved July 17, 1912, which authorized the payment of periodic cash rewards for the most valuable suggestions submitted by employees. So far as I know this act is the first successful effort on the part of any executive department of the Government to recognize in a material way those praiseworthy efforts of its employees which are outside of their ordinary work and for which their regular wage cannot be considered a fair compensation. In addition it affords another practical instance of the desire of this department to deal fairly with its employees and to promote that community of interest and close coöperation which both equity and efficiency demand. The necessary instructions for putting the act into effect have been issued, in accordance with which the first period within which rewards may be won will be from October 1 to December 1 of this year.

SCIENTIFIC MANAGEMENT AS APPLIED TO WOMEN'S WORK

CHAPTER VII IN "MAKING BOTH ENDS MEET," BY SUE AINSLEE CLARK AND EDITH WYATT

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WITHIN the last thirty years a new method of conducting work, called Scientific Management, has been established in various businesses in the United States, including "machine shops and factories, steel work and paper mills, cotton mills and shoe shops, in bleacheries and dye works, in printing and bookbinding, in lithographing establishments, in the manufacture of typewriters and optical instruments, in constructing and engineering work — and to some extent — the manufacturing departments of the Army and Navy."[1]

Three of the enterprises to a greater or less degree reorganized by this new system in this country employ women workers. These establishments are a New Jersey cotton mill, a bleachery in Delaware, and a cloth finishing factory in New England. The reduction of costs for the owning firms inaugurating Scientific Management has already received a wide publicity. It is the object of this account to present as clear a chronicle as has been obtainable of the effect the methods of Scientific Management have had on the fortunes of the workers — more especially on the hours, the wages, and the general health of the women workers in these houses who have so far experienced its training.[2]

[1] Brief on behalf of Traffic Committee of Commercial Organizations of Atlantic Seaboard, p. 70. Louis D. Brandeis.

[2] Fourteen years ago Scientific Management was applied to women's work in a Rolling Machine Company in Massachusetts. Here the women's hours were reduced from 10½ a day to 8½; their wages were increased about 100 per cent; and their output about 300 per cent. All the women had two days' rest a month with pay. The work consisted in inspecting ball-bearings for bicycles. Their department of the business, however, closed twelve years ago. Accurate facts other than those listed concerning the workers' experience as to hours, wages, and general health under Scientific Management are at this date too few to be valuable.

What, then, are the new principles of management which have been inaugurated? What is Scientific Management? The expression may perhaps best be defined to lay readers by a lay writer by means of an outline of the growth of its working principles in this company — an outline traced as far as possible in the words of the engineers creating the system, whose courtesy in the matter is here gratefully acknowledged.

I

In 1881, Mr. Frederick W. Taylor, the widely reverenced author of the "The Art of Cutting Metals" and of "Shop Management," then a young man of 21, closed, in grave discouragement, a long, hard, and victorious contest of his conducted as gang boss of the machinists of the Midvale Steel Company in Pennsylvania. In the course of the last three years, as he narrates in his book *Principles of Scientific Management*:[1] —

By discharging workers, lowering the wages of the more stubborn men who refused to make any improvement lowering the piece rate and by other such methods, he (the writer) succeeded in very materially increasing the output of the machines, in some cases doubling the output, and had been promoted from one gang boss-ship to another until he became the foreman of the shop. . . . For any right-minded man, however, this success is in no sense a recompense for the bitter relations which he is forced to maintain with all those around him. Life which is one continuous struggle with other men is hardly worth living. . . . Soon after being made foreman, therefore he decided to make a determined effort in some way to change the system of management so that the interests of the workmen and the management should become the same instead of antagonistic. . . . He therefore obtained the permission from Mr. William Sellers, the President of the Midvale Steel Company, to spend some money in a careful scientific study of the time required to do various kinds of work.

Lack of information on the part of both workers and the management as to the quickest time in which a piece of work can be done constitutes what has been the most formidable obstacle in the path of all progress toward improved industrial conditions. . . . Every wasteful operation, every mistake, every useless move has to be paid for by somebody, and in the long run both the employer and the employee have to bear a proportionate share . . . For each job there is the quickest time in which it can be done by a first class man; this time may be called the "Standard Time," for the job. . . . Under all the ordinary systems this quickest time is more or less completely shrouded in mist.

[1] *Principles of Scientific Management*, by F. W. Taylor.

Through a period of about twelve years the simplest operations in the shop were now timed, observed, and studied by graduates from science courses, different university men, engaged by Mr. Taylor, until a general law had been discovered regarding the exertion of physical energy a first class worker could employ "and thrive under." It was found that the worker's resistance of fatigue in lifting and carrying the load depended, not on the amount of strength in terms of horse-power which he was obliged to exert to elevate and sustain the load, but on the proportion of his day spent in rest. For instance, a pig-iron handler, lifting and carrying pigs weighing 92 pounds each, could lift and carry 47 tons of iron in a day without undue fatigue if fifty-seven per cent of his working hours were spent in rest, and forty-three per cent were spent in work. If he lifted and put in place a number of pigs amounting to half that tonnage, he might work without undue fatigue for a greater part of the day. Under a certain far lighter load he could work without fatigue all day long, with no rest whatever.

With accurate time study as a basis, the "quickest time" for each job is at all times in plain sight of both employers and workmen, and is reached with accuracy, precision, and speed.

Here is an account of the effect the result of this time study and these tests in strength produced on the output and wage of a group of men at the Bethlehem Steel Co., whose work Mr. Taylor reorganized after that of the Midvale Steel Company: —

The opening of the Spanish War found some 80,000 tons of pig-iron piled in small piles in an open field adjoining the Bethlehem Steel Company's works. Prices for pig-iron had been so low that it could not be sold at a profit, and was therefore stored. With the opening of the Spanish War the price of the pig-iron rose, and this large accumulation of iron was sold. The . . . steel company's . . . pig-iron gang . . . consisted of about 75 men . . . good average pig-iron handlers, under an excellent foreman. . . . A railroad switch was run out into the field, right along the edge of the piles of pig-iron. An inclined plane was placed against the side of a car, and each man picked up from his pile a pig of iron weighing about 92 pounds, walked up the inclined plank, and dropped it on the end of the car.

We found that this gang were loading on the average of about 12½ tons per man per day in this manner. We were surprised to find, after studying the matter, that a first class pig-iron handler ought to handle between 47 and 48 tons per day, instead of 12½ tons, which were being handled.

This task seemed so very large that we were obliged to go over our work several times before we were sure we were absolutely right. . . . The task which faced us as managers under the modern scientific plan . . . was . . to see that the 80,000 tons of pig-iron were loaded on the cars at the rate of 47 tons per man per day in place of 12½ tons. . . . It was further our duty to see that this work was done without bringing on a strike among the men, without any quarrel with the men, and to see that the men were happier and better contented with loading at the new rate of 47 tons than they were when loading at the old rate of 12½ tons.

The first step was the scientific selection of the workmen. . . . Under . . . scientific management . . . it is an inflexible rule to talk to and deal with only one man at a time, since we are not dealing with men in masses, but are trying to develop each individual man to his highest state of efficiency and prosperity. The 75 men in the gang were carefully watched and studied for three or four days, at the end of which time we had picked out four men who were believed to be physically able to handle pig-iron at the rate of 47 tons per day. A careful study was then made of each of these men. . . . Finally one man was selected from among the four as the most likely man to start with.

This man, who had been receiving $1.15 a day, agreed to follow for $1.85 a day the directions of the time student, who had determined the proportion and intervals of rest necessary for the regular accomplishment of the task, without overstrain or undue fatigue. The worker started to carry his accustomed load and at regular intervals was told by the time student, observing the proper period for rest and work with a watch: "Now pick up a pig and walk. Now sit down and rest. Now, walk — now, rest, etc."

He walked when he was told to walk and rested when he was told to rest, and at half past five in the afternoon had his 47½ tons loaded on the car. And he practically never failed to work at this pace and to do the task that was set him during the three years that the writer was at Bethlehem. . . Throughout this time, he averaged a little more than $1.85 a day; whereas he had never received more than $1.15 a day, which was the ruling wage at that time in Bethlehem. . . . One man after another was picked out and trained to handle pig-iron at the rate of 47½ tons a day, until all of the pig-iron was handled at this rate, and all of this gang were receiving sixty per cent more wages than other men around them.

A very brilliant and extended investigation concerning the elimination of waste of human energy and labor by motion study has been made independently of Mr. Taylor by Mr. Frank Gilbreth, whose discoveries in the field have already cut down the effort of the labor of bricklaying two-thirds. . . .

These extremely simple processes of bricklaying and carrying pig-iron have been selected as instances of the procedure of Scientific Management, because they reveal one of its most illuminating qualities. Scientific Management makes an art of all work. It gives the most primitive manual task its right dignity, and turns knowledge, science, and the powers of direction from the position of tyrants of labor to that of its servitors.

Scientific Management, then, besides eliminating waste in human energy, or rather by way of eliminating this waste, eliminates waste in equipment, waste in machine power, and evolves through an extended planning department such better appliances, such an improved program of work and recording of individual work as has been only very imperfectly indicated here. . . .

"But these," said Mr. Taylor, in speaking of the methods of Scientific Management, "are incidents in the course of Scientific Management. Its great underlying purpose is the achievement of prosperity for the workers and for the employers." Mr. Taylor's definition of prosperity, given on another occasion, is one of the finest the present writer has ever heard. "By a man's prosperity, I mean his best use of his highest powers."

It may be asked, after the efficiency of workers has been increased by scientific study, what provision is made by scientific study for their increased compensation. While Mr. Taylor was at the Bethlehem Steel Company, Mr. Henry L. Gantt, then engaged with him in reorganizing the Bethlehem Steel Works, first applied the Bonus and Task System of compensation, which may be described loosely as a premium paid if a certain predetermined amount be accomplished in a certain time. Its general principles are these:[1] —

1. "A scientific investigation in detail of each piece of work and the determination of the best method and the shortest time in which the work can be done."

2. "A teacher capable of teaching the best methods and shortest time."

[1] *Work, Wages and Profits*, pp. 110 to 111. H. L. Gantt.

3. "Reward for both teacher and pupil, when the latter is successful." [1]

II

About five years ago Mr. Gantt was consulted concerning the application of Scientific Management in a New England Cloth Finishing house. The installation of the new system here began on the eve of a strike which the workers lost. The history of this strike and its causes is not a part of this account. Only these facts concerning it bear upon the present subject. The strike started among the men folders, then folding 155 pieces of cloth a day for $10 a week on week wages, and asking for ten per cent increase of wage without increase of output. The women folders' wage on lighter work was $7.50. As will be seen, this request was met by Scientific Management. The wage was increased far beyond ten per cent. The output was increased both by improved mechanical methods, and by a standard of more expert work, to from 447 to 887 pieces a day. The engineers of Scientific Management had not on either one side or the other any part whatever in the strike. But undoubtedly one of its contributing causes was a distrust aroused by the rumor that a new system of work was to be inaugurated.

The Cloth Finishing establishment bleaches, starches, and calenders dimities, muslins, percales, and shirtings, and folds and wraps them for shipping. The factory has good light and good air and an excellent situation in open, lightly rolling country. About two hundred young women, Americans, Scotch, English, and French Canadians are now employed here on the bonus and task system, most of them whom I saw living with their families in very attractive houses in pleasant villages near. One or two were on the gloomy, muddy little streets of a French Canadian mill town. These girls, too, were in well-built houses and not living in crowded conditions. But all their surroundings were dingy and disagreeable. At the Cloth Finishing factory and

[1] While the bonus system as a means of compensation has been used very often in connection with the Scientific Management, it must not, however, be supposed that this method of compensation is alone and in itself Scientific Management. In fact, as employed without Scientific Management, it is to be regarded with some apprehension.

both the other establishments, every opportunity for the fullest inquiry among workers as to the result of the system for them was offered by the owning companies. Difficulties in the industry for the workers were frequently pointed out by managers; and the addresses and names of the less well-paid workers and those in the harder positions were supplied as freely as information about the more fortunate effects of the system. Both this firm and that of the cotton mill are anxious to obtain first class work through first class working conditions as rapidly as trade conditions will allow.

The first process at which women are employed is that of keeping cloth running evenly through a tentering machine. The machine holds on tenter hooks — the hooks of the metaphorical reference — the damp cloth brought from the process of bleaching, and rolls it through evenly into a drier, where it slips off. There are two kinds of tentering machines. At one kind two girls sit, each watching an edge of the cloth and keeping it straight on the tenter hooks, so it will feed evenly. The newer machines run in such a manner that one girl who may either stand or sit can watch both edges. Because of the nearness of the drying closet, the air would be hot and dry here but that outside air is driven in constantly by fans through pipes with vents opening close to the workers.

The tentering machines used to run slowly. This slowness enhanced the natural monotony and wearisomeness of the work. The girls used to receive wages of $6 a week, and to rest three-quarters of an hour in the morning and three-quarters of an hour in the afternoon, with the same period for dinner at noon in the middle of a ten-and-one-half hour day. After Scientific Management was introduced, the girls sat at the machine only an hour and twenty minutes at a time. They then had a twenty-minute rest, and these intervals of work and rest were continued throughout the day by an arrangement of spelling with " spare hands." The machines were run at a more rapid rate than before. The girl's task was set at watching 32,000 yards in a day; and if she achieved the bonus, as she did without any difficulty, she could earn $9 a week. The output of the tentering machines was increased about sixty per cent.

The girls at the tentering machines praised the bonus system eagerly. They said they could not bear to return to the former method of work; that now the work was easier and more interesting than before, and the payment and the hours were better. One of the "spare hands" showed me, as a memento of a new era at tenter-hooking machines, the written slip of paper the efficiency engineer had given to her, explaining to her how to arrange the intervals of rest, and to start the "rest" with a different girl on each Saturday — a five-hour day — so that the same girls would not have three intervals of rest every Saturday.

But in another part of the factory the girls at the tentering machines had wished to lump their rest intervals and to take them altogether in fifty-minute periods in the middle of the morning and of the afternoon. Here the "spare hands" intervals at the machines fell awkwardly, and they were obliged to work for an unduly long time. The girls became exhausted with the monotony in these longer stretches of work; and further wearied themselves by embroidering and sewing on fancy work in the long rest periods. Here the girls were much less contented than in the other departments.[1]

After the cloth is dry and passed through calendering machines where men are employed, it is run into yard lengths by a yarding machine or "hooker." At the yarding machines the girls stand under the frame holding the wooden arms that measure off the cloth back and forth. The workers here used to earn $7.50 a week. They watch the machine, mark defects in some kinds of cloth, by inserting slips of paper, stop the machine when the material runs out, and lift the pile of measured cloth to a table where it is taken up by the cutters and folders and inspectors.

After the bonus system was introduced at the machines where the heavier material is measured, the yarding machines were all elevated to small platforms, so that the pile when finished would

[1] The work in this department was, besides, rather slack at the time of year when I visited the factory, and wages for some of these workers were $6 a week, as low as they had been before the bonus was introduced.

be on a level with an adjacent table, and the worker need not lift and carry the heavy weight of cloth to the table, but could slide the work. The machine was run more rapidly. The task was increased to about 35,000 yards, or from about 155 pieces to about 610. The wage with the bonus was now about $10 on full time, and the hours were lessened 45 minutes, as at the tentering machines.

The worker stops the yarding machine by throwing her weight on her right foot, on a pedal to the right. The girls interviewed said they did not feel this as a strain, as there was a knack in doing it easily. On consulting a neighborhood physician it was found that within the last ten years, however, several women, both at the yarding and tentering machines, had strained themselves, probably by the tread at the yarding machine and by the slightly twisted seated position the older tentering machines necessitated. The number of these cases traceable to any one process of work had not increased under the new system. The whole number of these cases in the factory had, on the other hand, either decreased under the new system, or else had not come under this doctor's care. He believed, however, that there was a reduction of the cases, and that this reduction was attributable to the better general health achieved by shorter hours, better ventilation, and better working conditions and appliances.

The increased task at the yarding machine seems to have increased the danger of accidents. A knife extends from the side of the machine; and when the girl's attention is concentrated on her work, she sometimes puts her fingers too near the blade, and cuts them, though no instance was known here of the loss of a finger or of serious injury.

The girls stand all day at the yarding machine and at most of the succeeding processes of preparation. These are various arrangements of inspecting, counting yards, folding in "book folds," of doubled-over material, or "long folds" of the full width, ticketing and stamping, tying selvages together with silk thread, or tying them to wrapping paper by means of a little instrument called a knot-tier — this process is called knotting — tying with ribbons, pasting on strips of silver tissue ribbon, further ticketing and stamping, and running the sets of tickets indicating the several yards in each piece through an adding machine, which then produces on a stamped card the total number of yards in each consignment, before it is finally rushed away for shipment.

The process of inspection is different for different qualities of material. Before the material is bleached, the number of yards and the character of treatment for each piece are specified on stamped orders issued from the planning room and sent with the cloth through the processes of production. It may as well be said here, that several girls have been promoted from manual work to work in this planning room, where they stamp orders on a bonus at different rates, giving them a wage of about $10 a week in full time on office hours of 8 hours a day.[1]

The inspector receiving the bales from the yarding machines now counts off the number of yards and cuts the bale in accordance with these directions. Some material she inspects yard by yard for imperfections and dirt. After marking the yards on the cut piece, she sends it on to the folder if it is clean, and if it is spotted to girls who wash out the spots and press the cloth.[2] On other material, imperfections are marked by the girl at the yarding machine, by the insertion of slips of paper. As the inspector has less to do on these pieces, she not only counts and cuts, but folds them.

Before the introduction of the bonus system, one girl used to fold, inspect, and ticket. She used also to carry her material from a table near the yarding machine. Boys now bring the material except where at the yarding machines for heavier stuffs it is pushed along the table. The hours, as for almost all of the bonus workers, have been shortened by 45 minutes. The wages which were $7.50 a week are now between $10 and $11 on full time. Almost all the workers here said they greatly preferred the bonus system and would greatly dislike to return to other work.

[1] The girl who directs them and issues the orders receives a bonus for every stamper earning a bonus and earns on full time from $12 to $15.

[2] These girls are not employed under the bonus and task system. But it is interesting to observe that they may either sit or stand to iron, as they prefer.

But in dealing with the heavier materials the work was tiring, and more tiring under the new system than before, as the number of pieces lifted had been increased. It was said while there was every intention of fairness on the part of the management in arranging the work, it was sometimes not evenly distributed in slack times, the same girls being laid off repeatedly and the same girls chosen to work repeatedly instead of in alternation.

In the further processes of folding, some of the work and the lifting to the piles of the sheer, book-folded stuff is light, but requires great deftness; other parts of the work and the lifting to the piles are heavier.[1] The wage before the bonus was introduced was $7.50 a week, and with the bonus rose to $11 a week, in full time. As with the inspectors, the work was now brought to the folders, and the hours were shortened by 45 minutes. Here there was great variation in the account of the system.

One of the folders on light work, a wonderfully skilful young woman, who had folded 155 pieces a day before, and now folded 887, could run far beyond her task without exhaustion and earn as much as $15 a week. She and some of the expert workers paused in the middle of the morning for 10 or 15 minutes' rest and ate some fruit or other light refreshment, and sometimes took another such rest in the afternoon.

Another strong worker, employed on heavy material, though she liked the bonus system, and said " it couldn't be better," had remained at work at about the same wages as before, because she was a little ahead of the others before and earned $8 a week; and now, as there was hardly more than enough of her kind of work to occupy her for more than four days a week, she still earned about $8.

One folder was made very nervous by a constant fear that she would not earn her bonus. She always did complete the necessary amount; but when the system was first introduced, she had been sleepless night after night. Though this sleeplessness had passed away, she still took a nerve tonic to brace her through her work; and this was the case with another folder. The mothers of both

[1] The men folders at the heaviest work here now receive with the bonus from $14 to $17 a week.

these girls urged them to return to week work. But this was of poor quality — odds and ends — and the girls disliked it, and persisted in the new system.

In tying ribbons around the bolts of material, the girls sit at work. Their wages had been $1 a day for tying ribbons around 600 pieces; and now, on a bonus for 1200 pieces, is at times for quick workers, as high as $11. But the ribbon tying was not steady work. It is applied to only some of the material, and the task and bonus here are intermittent. The girls who knot, or run silk threads through the selvages, paste on tinsel ribbon, and wrap are younger than the other workers. Their wages before had been from $5.80 to $6 a week. Now they are in some cases over $8; in others about $7; in others about $6. The work reaches them in better condition than before. They said it was more interesting, and the chief difficulty was in lifting occasionally a greater number of heavy pieces in piling. Seats were provided for these workers except for those at tinselling; and if they found they were able to complete the task easily, they sat at the work. At the heavier work, the girl at yarding, the folder, knotter, and ticketer, all worked tandem, and if the girl at yarding loses her bonus, all the girls lose the bonus.

In the last process of stamping tickets and ticketing, the girls work without one superfluous motion, with a deftness very attractive to see; and both here and at book folding justify the claim made by Scientific Management that speed is a function of quality. The wages here had been $6 before, and were now in full time from $9 to $10. As the task before had been combined with various other processes, it was, as in other cases, impossible to determine how much the work of each worker had been increased. The present task was that of ticketing 39 bundles of 5 pieces each hourly, with different rates for different amounts of tickets, and was not considered at all a strain. But at the ticketing connected with the adding machines the work was not differentiated so carefully. More of the heavy work came to these ticketers, and the lifting was sometimes too exhausting. But the work was better than in former times, and the wages of from

$9 to $10 were thought just, if a higher rate had been added for the heavier work here.

III

All this work described at the tenter hooking, the yarding, the folding, inspection, and ticketing was of a different character from that carried on under the bonus and task system in a large room where sheets and pillow-cases were manufactured. This work afforded the only instance of an application of Scientific Management to the processes involved in the great needle trades and was, on that account, of special interest.

The white cloth is brought on trucks to the girls, who tear it into lengths, in accordance with written orders received with each consignment. They snip the cloth with scissors, place the cut against the edge of an upright knife, set at a convenient height on a bench, and pull the two sides of the cloth so that the knife tears through evenly to the end; then they stamp the material, fold it over, and place it on a truck to be carried to the machine sewer. The weekly wages before the bonus was introduced had been $5.98 and were now with the bonus $6.75, though workers sometimes tore more than the 1190 sheets required by the task and made from $7 to $7.50 by a week's work. The quick workers occasionally stopped for 10 or 12 minutes in the morning and ate a light lunch. The task was severe for the muscles of the hand and forearm, and apt to cause swollen fingers and strained wrists, though the girls bound their wrists to prevent this. All the work was done standing. The loosened starch flying here was annoying, both to the tearers and the girls at the sewing-machines.

Since the time of the inquiry, all the girls engaged in tearing have been relieved and transferred to other positions, and the work of tearing has been done by men.

Here the sheets are turned back and hemmed by workers who sew tandem, one girl finishing the broader hem and the other the narrower one, their task being 620 sheets a day. The girls at the machines formerly earned $7.50, and now earn with the machine set at the higher rate of speed from $8 to $11. They stop for 10 minutes in the morning, and clean the machines and clear away the litter around them. The sewing and stooping are monotonous, and the work on bonus here is apt to cause nervousness because of uncertainty occasioned by frequent breakages in the machines.[1]

There is a room at one side of the department, where the girls were to rest when they had completed their tasks. But the present foreman, not understanding the system, comes to the rest room and hurries them out again, even after the 620 sheets are finished.[2] One of the girls in the department, an Italian girl who used to run far beyond the task at the machine, had fallen ill under the strain of the work, or at least left the factory looking extremely ill and saying that she had broken down and could not remain. Another unfortunate result of the speed at the sewing-machines is that the girls are more apt than before to run the needles through their fingers.

The folding in this department is also exhausting, and the management is trying to find a better system of conducting this process than that now employed. The folders here stoop and pick up the sheets and fold them lengthwise and crosswise. The task is 1200 a day; and the wage with the bonus comes to between $6 and $7 a week. But after the bonus is earned, payment is, for some reason, not suitably provided on work beyond the task. One worker said she used to fold one or two pieces above the amount without any objection, but lately she had folded as many as 200 beyond, without payment.[3]

From the folders the sheets are carried away to a mangle where they are folded over again by young girls. The work is light, but the payment of $5.80 to $6 for 770 pieces an hour is low. The mangle is well guarded. By an excellent arrange-

[1] A worker does not lose her regular wage if she is stopped by a breakage. Her time card is altered. And she has credit on a time basis for the period while the machine is not running. A breakage in the first machine of a tandem pair stops both sewers. But a breakage in the second means that work piles up for the second sewer, and unless she makes it up, she will prevent her companion from earning a bonus, though not a time wage.

[2] The management, on learning of this, said the practice would be stopped at once.

[3] This must have been due to a misunderstanding of the Gantt bonus. Mr. Gantt's arrangement provides for payment for work in excess of the task set on a piece rate basis determined by the earnings at the task point. — Ed.

ment here, the material is piled on a small elevator, so that the girl at the mangle does not have to stoop or lift, but easily adjusts the elevator, so that she can feed the mangle from the pile at her convenience. The girl at a mangle can earn from $7 to $8 and is not tired in any way by her work.

The final stamping and wrapping in paper and tying with cord are done at a rate of 25 pieces an hour, for a wage coming to $6 a week, by young girls; and the situation is otherwise about the same as with the other wrappers.

Except at the mangle, the operation of the sheet and pillow-case factory was unsatisfactory to the management, who had begun to study the department for reorganization just before the time of the inquiry. Competition had so depressed the price of the manufacture of sheets that the commission men, for whom these processes described were executed, paid 25 cents a dozen sheets for the work. This does not, of course, include the initial cost of the material. It means, however, that all of the following kinds of machine tending and manual labor on a sheet were to be done for 2½ cents: —

Tearing (men workers)	Book-folding (women workers)
Hemming (women workers)	Wrapping (women workers)
Folding (women workers)	Ticketing (women workers)
Mangling (women workers)	

The management lost in its payment for labor here, and yet felt the work was too hard for its workers, and should be changed. Alterations in the rest periods are now being introduced. For the girls the system of operation at the time of the inquiry in the sheet and pillow-case factory, except on the mangle, was undoubtedly more exhausting than the old method, though their wages had been increased and their hours shortened.

In general in the Cloth Finishing establishment Scientific Management had increased wages.

It had shortened hours.

In regard to health and fatigue, outside the sheet factory, when the general vague impression that the new system was more exhausting than the other was sifted down, the grist of fact remaining was small, and consisted of the instances mentioned.

About forty young women told me their experience of the work. Sometimes their mothers and their fathers talked with me about it. Every one whose health had suffered under the new task had been exhausted by some old difficulty which had remained unremedied. This point will be considered in relation to the industry of the other women workers in the other houses after the accounts of their experience of Scientific Management.

IV

There are over 600 workers in the New Jersey cotton mill. Of these 188 are women. One hundred and ten of the women workers are at present engaged under the bonus and task system, though the management expects to employ eventually under this system all of its workers, and is in this establishment markedly in sympathy with Scientific Management. The mill is a large, well-lighted brick structure, with fields around it, and another factory on one side, on the outskirts of a factory town. The establishment is composed of a larger and newer well-ventilated building, with washed air blown through the work-rooms; and an older building, where the part of the work is carried on which necessitates both heat and dampness to prevent the threads from breaking.

The cotton, which is of extremely fine quality, comes into the picker building in great bales from our southern sea-coast and from Egypt. It is fed into the first of a series of cleaners, from the last of which it issues in a long, flat sheet, to go through the processes of carding, combing, drawing, and making into roving. The carding product consists of a very delicate web, which, after being run through a trumpet and between rollers, forms a "sliver" of the size of two of one's fingers, from which it issues in a long strand. This strand or sliver is threaded into a machine with other ends of slivers and rolled out again in one stronger strand; and this doubling and drawing process is innumerably repeated, till the final roving is fed into a machine that gives it a twist once in an inch and winds it on a bobbin. There are three kinds or stages of twisting and winding-roving on these machines, and at the last, the "speeders," women are employed.

Up to this point all the workers have been men. These speeders are in the carding rooms, which are large and high, filled with great belts geared from above, and machines placed in long lanes, where the operatives stand and walk at their work. Humidifying pipes pass along the room, with spray issuing from their vents. The lint fibres are constantly brushed and wiped up by the workers, but there is still considerable lint in the air. The heat, the whir of the machines, the heaviness of the atmosphere, and the lint are at first overpowering to a visitor. While many of the girls say that they grow accustomed to these conditions, others cannot work under them, and go away after a few days' or sometimes a few hours' trial.[1]

The speeders stand at one end of a long row of 160 bobbins and watch for a break in the parallel lines of 160 threads, and twist the two ends together when this occurs. The greater number of the speeders used to earn $6 a week. But two or three women, on piece work, earned about $9 and did nearly twice as much as the other workers. The speeders had helpers who used to assist them to thread the back of the machine and to remove and place the bobbins in front. The change or "doff" occupied about 20 minutes. It generally occurred five times in the day of the better worker and thus consumed an hour and forty minutes of her working time. The hours in the cotton mill are ten and a half a day with five and a half on Saturday, — 58 hours a week.

In order to ascertain the proper task for the speeders, a time study was made of the work of one of the abler workers, who may

[1] "The cotton as it grows in the field becomes more or less filled with blown dust. . . . Lint is given off in all processes up to and including spinning. . . . The only practical way to keep down the dust in all of these operations is by frequent sweeping and mopping the floor and wiping off the machinery." *Report on Condition of Women and Child Wage-earners in the United States.* Vol. I, p. 365.

"What degree of moisture is safely permissible from the standpoint of the operatives' health is an unsettled question. . . . When the operative after a day's work in a humid and relaxing atmosphere goes into one relatively drier, the assault on the delicate membrane of the air-passages is sharp. The effect of these changes is greatly to lower the vital resistance and make the worker especially susceptible to pulmonary, bronchial, or catarrhal affections. It is very possible that the dust and lint present in the mill have been credited with effects which are due in part to these atmospheric conditions." *Report on Condition of Women and Child Wage-earners in the United States.* Vol. I, p. 362.

be called Mrs. MacDermott, a strong and skilful Scotch woman, who had been employed at speeding in the mill for 14 years. Mrs. MacDermott was employed to teach the other speeders how to accomplish the same amount in the same time. The girls now thread the back of the machines with her help. Mrs. MacDermott, the speeder tender herself, and the doff boys, all working together, remove the bobbins and fill the frame, thus accomplishing the change in 7 minutes instead of 20 minutes. The girls are paid, while learning better methods from Mrs. MacDermott, at their old rate of a dollar a day. If they accomplish the task allotted, they receive a dollar a week more flat-rate, a bonus equivalent to a few cents a pound on each pound received by the management; and this brings the wage to $1.65 a day, or between $8 and $10 a week. The work tires the girls no more than it did before. They receive about thirty per cent more wages, and the management receives from the speeders nearly twice as great an output as before. Mrs. MacDermott's wage as a teacher has been raised to $12.

From the speeders, the doff boys send the roving — called fine roving in the mill, because the other rovings in preceding operations are coarser — upstairs in the older building to the spinners. Spinning is a more difficult task than speeding. Two rovings are here twisted together by the machines. The spinners have 104 bobbins on one side of a frame, and watch for breakage, and change the bobbins on three frames, or six "sides." Spinners formerly worked at piece work rates and by watching eight sides, and frequently doing the work very imperfectly, would earn about $9. After a time study was taken, the task was set at six sides, and doffs as called for by a schedule. With the bonus the girls' weekly wage comes to about $10. In the spinning department there is a school for spinners. The heads receive a dollar for every graduate who learns to achieve the task and bonus.

The yarn is carried from the spinners to the spoolers, and wound from bobbins to spools for convenience in handling. The work of the spool tenders seemed to the present writer to be the severest work for women in this cotton mill. The bobbins run out very rapidly, and require constant change. The girls watch the thread for breakages just as at the other machines. In replacing the bobbins and fastening the broken threads with a knot tier, the girls have to stoop down almost to the floor. Before the time study was taken, the girls were watching 75 bobbins, hurrying up and down the sides, bending up and down perpetually at this work. Some of the spool tenders had $6 a week on piece work; others, more experienced workers, were able to earn $10.50 at piece work, although the work was frequently unsatisfactory and had loose ends. A little Italian girl, who may be called Lucia, an extremely rapid worker, used to run wildly from one end of the frame to the other, and in the summer-time fainted several times at her work from exhaustion. A time study was taken from the work of a very deft young Polish girl, and from Lucia. The other spoolers were taught to work with the same rapidity, and were soon able to earn with the bonus and the work done beyond the task a sum which brought their wage up to nearly $12 a week.

This lasted for about two months. But the work was so improperly done and the spools were so full of loose and untied ends, etc., that the number of spindles to be tended was reduced from 75 to 50, and the machines were run at a lower rate of speed. The task was changed accordingly so that the worker's wage, simply with the bonus, was as it had been before. But she was unable to overrun the task as far as she had formerly. By the workers' constant attention, the work now improved in quality, but the limit of quantity, was, of course, lower. The wages with the bonus dropped back to a smaller excess, or $1.47 a day. This was, of course, disheartening, though Lucia said it was better, she was so much less tired by the work than she had been before. But the work is still undoubtedly very wearying and difficult. The spoolers still give incessant attention to their work, still do their best, and yet make by close application far less than they had grown accustomed to expect whether justly or unjustly.[1] The task is now 12 doffs a day — each doff requiring a change of 208 bobbins. So that in changing bobbins alone the

[1] Besides, work had lately been slack, and this had further decreased the wages.

girls have to stoop down over 2000 times a day, without counting all the stooping for knot tying, which the forewoman said would about equal the labor of bending and working at bobbin changing She had talked with the management about having the frames raised, so as to eliminate this exhausting process of stooping to work for the spoolers. This change had been made in two machines and will doubtless be extended.[1]

At the further twisting and plying of the cotton, the processes succeeding the spooling, men are employed. From these the yarn goes to the winding room in the newer building, where better air and temperature are possible than in the carding and spinning rooms. The winding room is large and light. At one side stand the warps, very tall and interesting to see, with their lines of delicate filament and high tiers of bobbins. In the winding room girls are engaged at machines which wind the yarn from spools back to bobbins for filling in the looms and also for the warp.

In winding the filling bobbins the girls watch the thread from eighteen bobbins, and replace and stop bobbins by pressing on foot pedals. The worker had made from $7 to $7.50 a week before a time study was taken and the task increased. She can now make from $8 to $10.50 a week. The work is lightened for her by the fact that whereas she formerly placed the bobbins on the warp, doffers now do this for her. But the increased stamping of the pedals made necessary by the larger task is very tiring.

There are no women on bonus in the weave room, where the warp and the filling are now carried. After the woven product comes from the weaving room — an extremely heavy, strong stuff of the highest grade, used for filter cloth and automobile tires — it is hung in a large finishing room in the newer building over a glass screen lighted with sixteen electric lights which shine through the texture of the material and reveal its slightest defect. After it has been rolled over the screen, it is sent to girls who remedy these defects by needlework.

[1] Since visiting the New Jersey cotton mill, the present writer has seen spool tenders at work at a machine requiring no stooping, and provided with a board below the bobbins, placed at such a height that the worker can relieve her position while standing by resting her weight against the board, above one knee and then above the other.

It is again run over the lighted screen by the inspectors and returned to the girls if there are still defects. Before the bonus system was applied, the girls had made $5.04 a week, and finished about 5 rolls a day. After the system was applied, they made from $7 to $8 and did sometimes 10 and sometimes 12 rolls a day. But, in spite of the greatest care on Mr. Gantt's part in standardizing the quality in this department, here, as with the spool tenders, requirement as to quality had recently caused a temporary drop in wages. This change in requirement was occasioned, not as at the spool tending by the negligence of the workers, but by the somewhat unreasonable caprice of a customer. Knots in the texture, formerly sewed down as they were, are now cut and fastened differently. To learn this process meant just as hard work for the girls, and put them back temporarily to their old day rate,[1] though they were recently becoming sufficiently quick in the new process to earn the bonus as well as before.

By and large, the wages of the women workers in the cotton mill had been increased by Scientific Management.

Their hours had not been affected. These were in all instances 10½ a day and 5½ on Saturday. There was no overtime. But on five nights in the week, women preparing yarn for the following day worked at speeding and spinning from six at night until six in the morning, with half an hour for lunch at midnight. This arrangement had always been the custom of the mill. The girls go home at six for breakfast, sleep until about half past four, rise, dress, and have supper, and go to work in the mill again at six. The night workers I visited had worked at night in other mills in New England before they worked in New Jersey. Their sole idea of work, indeed, was night work; and if it were closed in one mill, they sought it in another. One of the youngest girls, a clever little Hungarian of 17, who had been only 3 years in this country and could barely speak English, knew America simply as a land of night work and of Sundays, and had spent her whole life here like a little mole. The present owner, the superintendent, and the head of the planning department all seriously dis-

[1] At the same time work was so slack that week wages had dropped to $3 and $4.

liked night work for women, and said they were anxious to dispense with it. But they had not been able to arrange their output so as to make this change, though they intended to inaugurate it as rapidly as possible.

Concerning the health and conservation of the strength of the women workers in the mill under Scientific Management, the task of the speeders and of the women at cloth inspection tired the girls no more than it had before. In the spool tending and the winding, as the two most exhausting operations in each process, the stooping and the stamping of the pedals had been increased by the heightened task, the exhaustion of the workers was heightened. But the work of the excitable little spool tender mentioned was finally so arranged as to leave her in better health than in the days when she was employed on piece work, and the management was now endeavoring to eliminate the stooping at the bobbins. At spinning almost all the spinners found the work easier than before, probably because Scientific Management demands that machine supervision and assistance shall be the best possible. It must be remembered that the adjustment of conditions in the mill here is comparatively new. Almost all the girls said: "They don't drive you at the mill. They make it as easy for you as they can." It was of special value to observe the operation of Scientific Management in an establishment where all the industrial conditions are difficult for women. As in the white goods sewing for the Cloth Finishing establishment, these industrial conditions are unfortunately controlled to a great extent by competition and by custom for both the employer and the employees. The best omen for the conservation of the health of the women workers under Scientific Management in the cotton mill was the entire equity and candor shown by the management in facing situations unfavorable for the women workers' health and their sincere intention of the best practicable readjustments.

V

The application of Scientific Management to women's work in the Delaware Bleachery was very limited, extending only to about 12 girls, all employed in folding and wrapping cloth.[1] The factory, on the outskirts of a charming old city in Delaware, is an enormous, picturesque cement pile, reaching like a bastion along the Brandywine River, with its windows overlooking the wooded bank of the stream.

The girls stand in a large room, before tables piled with great bolts of material, and stamp tickets and style cards, fasten them to the roll, fold over the raw edges of the material in a lap, tie two pieces of ribbon around the bolt, wrap it in paper, stamp and attach other tickets, and tie it up with cord to be shipped. Here, after a time study was made of the quicker girls in all the operations, different tasks were set for different weights of material; and if the task was accomplished, a bonus was paid, amounting, roughly speaking, to a quarter of the worker's hourly wage. The arrangement of the different processes was so different for each worker, after and before the system was installed, that none of the girls could compare the different amounts of work she completed at the different times. But the whole output, partly through a better routing of the work to the tables, and by paying the boys who brought it a bonus of 5 cents for each worker who made her bonus, was increased from twenty-five to fifty per cent.

The girls' hours were decreased from 10¼ a day with frequent overtime up to nine at night to 9¼ a day with no overtime, the Saturday half-holiday remaining unchanged. Here is a list of the changes in the week wages. The work at the time of the inquiry was slack. Sometimes there were only a few hours in the day of wrapping of a kind on which the task and bonus was applied. Besides, these workers were in the midst of an establish-

[1] One of the girls issues batches of tickets. Another girl unfolds one end of certain of the packages, and inserts a ticket and stamps an outside label, to accord with the invoice system of some of the purchasers. These girls had received before $5.40 and $4.84 a week, respectively, and now receive, the one $5.73, and the other between $5 and $6.

ment managed by another system. The bonus was given on the basis of the former wage. And this remained lower in the case of workers employed fewer years by the firm, though sometimes their task was the same as that of workers employed longer. Where the girls wrapped both the heavier and the lighter materials, the allotment of these was in the hands of a sub-foreman, who, instead of being in the new position of a teacher rewarded for helping each worker to make her bonus, was in the old position of a distributor of favors. The slackness of the work had led the management, in a good-willed attempt to provide as well as pos-

	Per Week	Former
Folding and ticketing on light material........	$5 to 6	$4.84
Wrapping light material.....................	6 to 7	4.50
Wrapping light material.....................	7 to 8	4.84
Wrapping light and heavy material...........	6 to 6.50	4.50
Wrapping light and heavy material combined with napkin tying........................	6 to 7	4.84
Folding and ticketing both light and heavy material...................................	5 to 6	4.84
Folding and ticketing both light and heavy material (unaccustomed to the work)..........	4.59 (once 6.69)	4.50
Folding and ticketing both light and heavy material (unaccustomed to the work)..........	5	4.50
Folding and ticketing both light and heavy material (unaccustomed to the work)..........	3 to 5	7 (in another department)

sible for the employees, to place several girls from other departments under this sub-foreman. One of these less strong and experienced girls, at the time of the inquiry, was receiving such an amount of heavy work that she could wrap only enough of the task to enable her to earn from $3 to $5 a week. The firm's policy was paternalistic, and while in many ways it had a genuine kindness, it was not in general sympathy with Scientific Management, though the superintendent is a thorough and consistent supporter of the new system. But he had not been able, single handed, to achieve all the necessary adjustments, in spite of the decided increase of output the new methods had already obtained for the company.

Even considering slackness, these increases per week for first-rate speed and work, though in many cases the work was light, cannot but seem small. All the girls lived in attractive houses and pleasant places. All but one were with their families. The city has an open market. People of all grades of income go to market properly with market-baskets, choose food of excellent quality, and have fresh vegetables through the winter. The ladies of the house, the girls' mothers, preserve fruit from June strawberries to autumn apple-butter, and exhibit it proudly in row after row of glass jars. But the girls' wages could not pay for such living conditions. The girl who was boarding, and whose wages were sometimes $5 a week, could not always pay her board bill and had almost nothing left for other expenses.[1]

In regard to health and fatigue the main difficulty here, as at the Cloth Finishing factory, was in the lifting of heavier pieces of cloth. Two of the girls had suffered, since the introduction of the bonus and task, by straining themselves in this way. One of them was at home ill for a week, and is now quite well again. The other girl was away for two months, and though she is now at work, has not fully regained her health. The company had at once obtained employment less straining for the first of these girls, and the second said that the firm had always been fair with her in arranging the work. It was said that it had been Mr. Gantt's intention to have the heavier lifting done by men and boys, instead of combining it with the larger tasks the girls now accomplished under the new system. But the department had never fully carried out its intention, and unfortunately since Mr. Gantt's departure rather more of the heavy material had been ordered from the house than before.

The general good will of the firm, the picturesque factory site, the pleasant work-rooms, and the attractive living conditions of the Delaware workers gave them an extraordinary opportunity to pursue their labor healthfully. But because of its incomplete adoption, Scientific Management, though it had shortened hours,

[1] All the firms have rest rooms for the girls. The Delaware firm and the New Jersey cotton mill have pleasant lunch-rooms, where an excellent lunch is provided at cost.

and in most cases had raised wages, had proven of less potential value to the workers than to those in the more difficult industrial situation obtaining in the cotton mill.

VI

In general, then, Scientific Management for women workers in this country may be said as far as it has been applied to have increased wages, to have shortened hours, and to have resulted fortunately for the health of women workers in some instances and unfortunately in others.

Wherever a process presented a difficulty which remained unremedied, if the task were multiplied, the difficulty, of course, was multiplied. No matter how greatly the weight of a wagon is lightened, if there is a hole in the road of its passage, and the road is now to be travelled sixty times a day, instead of twenty times, as before, the physical difficulty from this hole is not only trebled, but while it may be endured with patience twenty times, is not only a muscular, but a nervous strain at the sixtieth. This was the situation in regard to all unrelieved heavy lifting wherever cloth was manipulated, the situation in regard to the stooping for the spool tenders, the stamping at the winding machine, and the stooping and breakages at the sewing-machine. But these points, instead of being ignored by the management, were seriously regarded by the employers as inimical to their own best interests in combination with those of their employees, and in all the establishments were in process of adjustment.

In the present writer's judgment this adjustment would have been inaugurated earlier in several processes and would have been more rapid and effective for both the employer's interest and that of the women workers if the women workers' difficulties had been fairly and clearly specified through trade organization. Such an organization would also be of value in preventing danger of injury for workers whose attention under Scientific Management should be concentrated on their tasks, and of value in supporting the tendency of Scientific Management to pay work absolutely according to the amount accomplished by the worker, and not under a certain specified rate for this amount.

Scientific Management as applied to women's work in this country is, of course, very recent. This synthesis of its short history is collected from the statements made by about eighty of the women workers, by Mr. Gantt, and by the owner, superintendent, and head of the planning department of the cotton mill, by the superintendent and one of the owners of the Cloth Finishing factory, and the superintendent and one of the owners of the Bleachery. The account should be supplemented by several general observations.

The first is that it is difficult to determine where the health of a worker has been strained by industry and where by other causes. Quite outside any of the narratives mentioned were those of two young women employed under Scientific Management whose health was hopelessly broken. Both of these poor girls were subject to wrong and oppressive maltreatment at home. Indeed, from oppression at home, one of the girls had repeatedly found refuge and protection in the consideration shown to her by the establishment where she worked. It was not she who blamed the new way of management for her breakdown, but people whose impression of her situation was vague and lacked knowledge.

The whole tendency of Scientific Management toward truth about industry, toward justice, toward a clear personal record of work, established without fear or favor, had inspired something really new and revolutionary in the minds of both the managers and the women workers where the system had been inaugurated. Nearly all of them wished to tell and to obtain, as far as they could the actual truth about the experiment everywhere. Almost no one wished to "make out a case." This expressed sense of candor and coöperation on both sides seemed to the present writer more stirring and vital than the gains in wages and hours, far more serious even than the occasional strain on health which the imperfect installation of Scientific Management had sometimes caused.

These strains on women's health in industry in America · stooping and monotony in all the needle trades, jumping on pedals in machine tending, dampness and heat in cotton production, the standing without pause for many hours a day throughout the month, the lifting of heavy weights in packing and in distribution — all these industrial strains for women constitute grave public questions affecting the good fortune of the whole nation and not to be answered in four years, nor by one firm. It is undoubtedly the tendency of Scientific Management to relieve all these strains.

No one can see even in part the complications of contemporary factory work, the hundred operations of human hands and muscles required for placing a single yard of cotton cloth on the market, the thousand threads spinning and twisting, the thousand shuttles flying, the manifold folding and refolding and wrapping and tying, the innumerable girls working, standing, walking by these whirring wheels and twisting threads and high piled folding tables, without feeling strongly that ours is indeed an industrial civilization, and that the conditions of industry not only completely control the lives of uncounted multitudes, but affect in some measure every life in this country today.

No finer dream was ever dreamed than that the industry by which the nation lives should be so managed as to secure for the men and women engaged in it their real prosperity, their best use of their highest powers. By and large, the great task of common daily work our country does today is surely not so managed either by intent or by result, either for the workers or for the most "successful" owners of dividends. How far Scientific Management will go toward realizing its magnificent dream in the future will be determined by the greatness of spirit and the executive genius with which its principles are sustained by all the people interested in its inauguration, the employers, the workers, and the engineers.

SCIENTIFIC MANAGEMENT AS VIEWED FROM THE WORKMAN'S STANDPOINT

What the Men thought of the Methods used in a Shop that increased its Production by Modern Methods of handling Men

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In the past few months there has appeared in the columns of *Industrial Engineering* considerable material on the scientific management of labor, its effect on the efficiency of the shop, and the benefits that will accrue to all hands by the adoption of its principles, rather than by adherence to the older type of " military " management. Much that has been written dealt with the question from the employer's side. Stress was laid on the fact that he could increase the quality and quantity of his product without the addition of new machinery. It was also stated that scientific management would totally eliminate labor troubles; of this last statement many owners and managers are probably skeptical, and perhaps with reason. It does, at first sight, appear improbable that a workman could be required to turn out from two to three times as much work as formerly, and have him remain contented at the same time. A skeptic of such a statement is fairly entitled to proof. We are now prepared to offer it.

In proving the statements as to the contentment of the worker, the employer's word need not be accepted. We can safely take his statements in regard to increase of product, and of quality of work, but for proof that the methods used to obtain this increase are not burdensome we must go to the men themselves. This the writer has done.

The Link-Belt Company, having shops at Philadelphia, Chicago and Indianapolis, operates these shops wholly under the principles of scientific management. In the main, the so-called " Taylor System " is in use. Modifications of the original system have been found advisable. One of the fundamental principles of scientific management is that all planning of the method of doing a job shall be done by a man, or men, especially trained for the work, and not by the man at the machine. Another is that the minimum time required to do a certain piece of work be accurately determined. The man is then given an instruction card telling him exactly how to do the work, and the time required for each piece if the instructions are followed. If the man does each piece in the time specified or less, he is given a certain price per piece. If he takes longer than the time specified, he is given another, and much lower, price per piece. This is what Mr. Taylor calls the "differential piece rate" plan of payment, and is the principal method used in the Link-Belt shops.

It was the writer's privilege, recently, to spend considerable time in the Philadelphia plant investigating the workings of the system of management there used, and its effects. As he was at one time, several years ago, and before the present scheme of management was installed, employed in this same plant, he was able to compare with some accuracy the results obtained under the old and new systems.

The officials of the company were most emphatic in their statements as to the value of the new order of management which has now been tried for over five years. From his knowledge of previous conditions in the shop, which even in the earlier days was one of the best managed in the country, the writer could see that from the employer's standpoint scientific management was an unqualified success. He, however, was most curious as to its effect on the men. It was immediately suggested by the superintendent that he get the information at first hand from the men themselves. He was allowed to wander around the shop and question the men at will.

It is interesting to note that the men do not know of any particular system of management in the shop. They know that if they do what is expected of them the earning rate is high, and if they do not, the earning rate is much lower. They refer to differential rate system as "two-rate piece work."

Invariably all conversations with the men led back to the subject of the pay envelope, and in every case the man volunteered the information that it was the amount of money he received on pay day that interested him. He did not object to working in any particular way desired by the boss, provided that he was able thereby to receive a fatter pay envelope. He soon learned that he could turn out the greatest amount of work by following the instructions given him, rather than by trying methods of his own. Therefore, as one workman put it, "I'm doing the work so as to get the most money, and the boss's way is the best way I know."

The writer talked with many of the men. The burden of the talk of all was the same; they had to work steadily; they had to pay strict attention to business; they had to follow the instructions given to them; but they made more money than they could in any other shop; the bosses helped them; the company treated them square, and you could not drive them out of the shop with a club.

A typical interview was that with one of the lathe hands. This man, at day work, was rated at 28 cents per hour. He stated that on the "two-rate piece work" his earnings were as high as 43 to 45 cents per hour. Questioned as to how much more he turned out at piece work than if he was on day work he said, "I don't know. You see it's been a long time since I was on day work, and on piece work we don't slow down any, for then we might get into the low rate, and we would make but little more than we do on day work." Asked then if he was not afraid that if he made high wages the rate would be cut, he replied, "No, the company's square. They never cut the rate. If they make a mistake and we made a little more than they wanted us to, they take their medicine and there's no kick coming." And be it known that when you have got a workman to say that the company is square, you have obtained the *last word on the subject*. There is *no higher praise possible*. And the *squareness* of the company is one of the most important factors in scientific management. We shall have more to say on this later.

"But," continued the workman, "if they make a mistake the other way, they fix it. If they give us a job and figure on taking two cuts over it, and we find the casting is made large, so that we have to take three cuts, or is hard so that we can't run as fast or take as heavy a cut as they want us to, or if anything happens that they didn't think of, so that it takes longer than they thought it would, all we have to do is to tell the gang boss. He puts it up to the office, and they make a new rate on the job. The mistakes are always on the company and not on us, if we do as they want us to." It will be well to keep in mind the above paragraph. It will explain to a great extent the duties of the "demonstrator" to appear later.

The workman was then asked if he had to work much harder at piece work than he would if the whole shop was on day work to which he replied in the affirmative. "But," he added, "it's this way: it is rather steadier than harder. I'm after the coin. I'm going to work where I can get the most. If I could get more over at Midvale[1] than I can here, I'd quit and go over to Midvale, even if I had to work harder than I do here. I don't mind the work. I get more money for doing it than I would if I was on day work some place else, so I'm staying right here as long as I can make good." This statement led to the question as to how soon a new man was expected to "make good" at the necessarily high pace that was the standard in the shop. It transpired that plenty of opportunity was given to become accustomed to the existing conditions. New men are put on day work for from four to six weeks, until they catch the spirit of the place. They are then put on piece rate, and the incompetent automatically weed themselves out. If they cannot maintain the standard set, they make a very low rate per piece, and possibly earn less than they would at day work in a shop where the average speed of working is lower. They therefore leave of their own accord, and it is seldom necessary to discharge a man for inefficiency. Consequently, all the men average up to a high standard, probably much above that found in most shops in Philadelphia.

The man was then bluntly asked if he would rather be on piece work than on day work — they are sometimes put on day work if the job has not been standardized, or if no time study of its

[1] Midvale Steel Works, an adjoining plant.

conditions has been made — and he replied, "If you saw the long face on a fellow on day work for a week you wouldn't ask that. Why, his pay envelope looks so thin that you 'd think there was nothing in it." From which it may be inferred that the piece work system, if conducted rightly, is not the unmixed evil it is often claimed to be by some misguided persons.

The man was next questioned as to spoiled work. It developed that if he spoiled a piece, he was expected to replace it on his own time — *i. e.*, he was not paid for the time required to make the new piece. He was also asked if there was much work spoiled. This subject was deemed important, as it has been claimed by opponents of advanced systems of management that the high speed required of the men is subversive to accuracy. The workman pointed out, clearly and forcibly, that he spoiled very little work. In the first place, he couldn't afford to. In the second place, in order to make the high rate he had to attend very strictly to his machine, and he did not allow his attention to be distracted while he was working. His instruction card told him plainly what to do, and if he followed instructions he could not go wrong. This testimony was later confirmed by the superintendent, who stated that the quality of work was much higher than it formerly was. In answer to a question as to whether he was any more fatigued at the end of the day than formerly, when he did not have to maintain such high speed, the man said he did not think he was. He said, that he was kept so busy all day that he did not have time to think of being tired. Quitting time came before he thought it was near due. Finally, the man expressed himself as being thoroughly satisfied with his job, and convinced that he was much better off than before the company began to pay him the way it was now doing.

Conversations with other men brought out practically the same facts. They are all contented. They took pride in their work, and seemed to be especially proud of the fact that they were employed in the Link-Belt shops.

Mention has been made in one of the previous paragraphs of the duties of the "demonstrator." It is necessary under the system used in the Link-Belt shops that when the time in which a piece of work is to be performed is fixed and the instruction card bearing this time is issued to the workman, the company be prepared to demonstrate to any workman that the work can be done in this time. The writer had related to him by the demonstrator an incident which showed the value of this provision. The demonstrator in this case also happened to be the man who sets the rates on all the work in the shop.

The incident related by the demonstrator was as follows: A new turret lathe had been installed and it was decided that a certain piece to be made in quantity should be manufactured on this machine. The rate setter had had no opportunity to run the machine in question or to make any time studies on it. However, from his knowledge of how the job had been done in other machines and from his general knowledge of machine work, he put a time of 23 minutes on the job. The card was issued to the workman early the next morning, giving instructions for this job and showing him the time in which it should be performed. The demonstrator was prevented by illness from showing up at the shop the next morning. The next day, when he appeared, he found considerable trouble in the shop. The man to whom the job had been assigned declared that it was impossible to do it in 23 minutes. He had appealed to the gang boss and to the superintendent who were powerless to change the time set in the absence of the rate setter. The workman was naturally very much disturbed. The superintendent and the gang boss were somewhat stirred up, as the man was one of the best workmen in the shop and they desired to aid him. They suggested that the rate setter either revise the rate or convince the workman that the job could be done in the time allowed. The rate setter, who now became the demonstrator, after a short conversation with the workman, said that although he had never run the machine he was sure that he (the demonstrator) could do the work in the time allowed. The workman offered to bet him that he could not do it in three trials. The demonstrator took him up and started in. On the first trial he made the piece in 23½ minutes; on the second trial he made in 22 minutes; and on the third trial in 19 minutes. The man who had been closely watching the motions of the demonstrator, then told him to get away from the machine, that if he could do it in 23 minutes, he was sure that he (the workman) could. On his first trial he made the piece in 21 minutes and subsequently, reduced the time to 17 minutes, which is now about what he usually requires on this job

The rate setter declared that 23 minutes was a very bad estimate on his part, and that if he had known the machine better, it would probably have been lower.

In many shops the temptation in this case would have been to cut the rate so that the man would have been regularly required to do the work in 17 minutes. The fact that this has not been done shows that the company thoroughly appreciates the necessity of acting fairly by its men and maintaining a rate when it has once been made. The fact that the company maintained this rate and others of like class, convinces the men that they have nothing to fear by working at their maximum pace and turning out the greatest possible quantity of work. They know that in no case will they be compelled to call the maximum rate, attained under probably exceptional conditions, the ordinary rate to be attained under any and all conditions. Because they thoroughly understand the necessity of keeping faith with the men is one of the reasons why the Link-Belt Company is able to retain in its employ such a large body of exceptionally fine mechanics, while working them at a much swifter pace than is the case in most every other shop in the country.

PREFACE TO THE FRENCH EDITION OF "THE PRINCIPLES OF SCIENTIFIC MANAGEMENT" BY FREDERICK W. TAYLOR

By HENRI LE CHATELIER

TRANSLATED BY ELEANOR BUSHNELL COOKE

The author of this volume, Frederick Winslow Taylor, is the well-known inventor of high-speed tools: his discovery has revolutionized all mechanical construction. It has doubled and tripled the output of machine tools, while increasing in the same proportion the daily production of the workmen. This remarkable increase in production and the corresponding decrease in the cost of the output, have produced very important economic consequences, of which the following is an example, among many others. An American company, The Pennsylvania Railroad, was preparing to double its machine shops, when the unexpected appearance of high-speed tools made it possible for them to double their output at a single stroke, and thus to abandon their plans for enlargement. In other places the economies effected through high-speed tools have brought about profound changes in the old methods of work, reversing, for example, the relative importance of forging and finishing. Many engineers engaged in mechanical construction and many mechanics are familiar with these facts and appreciate their importance.

After having exercised such an influence on the evolution of modern industry, the ideas of the great American engineer should command some attention. He attributes to his principles of *scientific management in machine shops* a still greater importance than to that of the discovery of high-speed tools. In the face of such a claim on his part, it would be unreasonable to refuse to study these new methods with the greatest care. It is obvious that no one can claim absolute infallibility, even after great accomplishments. Former successes, however, create a presumption in favor of the man who has made them.

The dominant idea of Frederick Taylor aims at an increase in the product of labor, without increasing the fatigue of the workman; and this increase in output leads invariably to a large increase in the man's wages. It is possible to accomplish this result because the output of each workman depends in all cases on a very considerable number of independent factors, or variables, to speak in mathematical terms. In the case of turning metals in a lathe, for example, Frederick Taylor has shown that the minimum number of these variables is twelve, each having an important bearing on the final result. Confronted by this complex problem, it is evident that the workman cannot, by mere guess work, discover for himself the most favorable conditions for the execution of the tasks assigned to him. To establish these *best adapted* conditions for lathe work, elaborate slide rules have been found indispensable. The study of the working of metals, one of the most important of the author's accomplishments, has cost more than $200,000 and required twenty-five years of work.[1]

Even the simplest shop operations are difficult to plan properly and are beyond the capacity of the workman. For example, the simple operation of loading pig-iron into cars involves very delicate physiological problems. The alternations of rest and labor, the rate of speed of each motion, the weight lifted at each effort, considerably modify the fatigue incident to a given task. By systematic motion study Mr. Taylor has succeeded in quadrupling the production of his workmen, without material increase of fatigue. He has made it possible for them to load 47 tons day after day, year after year, instead of the 12½ tons which had been their accustomed daily stint when left to themselves, while at the same time doubling their pay.[2] In like manner, a mason habitually makes five times as many motions as are necessary, when handling his bricks and mortar and laying them in place. A study of bricklaying made in Philadelphia and carried on for several years made it possible to produce in a given time nearly three times as much work as formerly.

[1] See the introduction to Taylor's "Art of Cutting Metals," republished in this book, p. 242. — ED.

[2] This should be "increasing their pay sixty per cent."

The opinions advanced in this book will certainly shock a great many employers, and a still greater number of workmen, because they are opposed to current ideas and prejudices. Frederick Taylor is manifestly in advance of his age; all the more reason for the closest examination of his ideas.

Scientific management or work in industrial establishments has for its essential object, the increase of individual productivity, and this is diametrically opposed to the cherished ideas of the labor unions of today. Their chief concern is just the opposite, namely, to limit the output of every workman, so as to assure work to a greater number of men, and thus to limit the number of the unemployed. Is it unreasonable to ask them to ponder a little over these problems, to study them at closer range, to devote a few hours of leisure to the reading of this little book?

In looking over the daily papers and the records of the Chambers of Deputies about the year 1840, the reader would appreciate the alarm occasioned by the introduction of railroads. It was feared that they were going to throw large numbers of people out of work; to take the bread from the mouths of all teamsters and *diligence* drivers, and to ruin agriculture by eliminating the use of horses. The peasants were not the only ones to express these fears; educated men occupying important positions in business and politics shared their apprehensions. In spite of these pessimistic prophecies, the number of horses and carriages in use is still increasing. Today no labor union would dream of advocating the elimination of railroads. They all see too clearly what a large part this means of quick communication has played in the increase of general wealth and in the development of prosperity among all classes of society. Are they then sure that they are not making the mistake of repeating the errors of their forefathers under another form, in opposing, as they are now doing, the development of better and quicker methods of production? To all workingmen reading these words, one may say in good faith, Stop and think!

The manufacturers are making an entirely different type of objection to the Taylor methods. They state that their application demands conditions that are not only very taxing, but also exceedingly difficult to realize. Foremen must be put in charge of the workmen who know the manual trade as thoroughly as their subordinates do: and yet the young engineers of today are more or less looked down upon by the skilled mechanic. At the same time, in order to apply efficiently the Taylor methods, these engineers must be thoroughly trained in scientific methods of great precision. In fact they are required to measure, almost to the fraction of a second, the time which the workmen placed under their authority take to make each motion, to move a foot or an arm. All this seems very complicated. If manufacturers, however, will look back to the state of manufacturing at about the time when railroads were first introduced, they will see a very different type of organization from that of today; infinitely more simple, infinitely less complex. There were at that time few if any engineers with scientific training; no laboratories, and the rule-of-thumb sufficed for everything that was made. Without a moment's hesitation, employers of that period would have considered it folly to install in manufacturing establishments either chemical laboratories or laboratories for mechanical experimentation; and still less those for physical research. And yet today these laboratories are found everywhere in the great industries. In some shops more than a hundred employees are engaged in work of this type. In the same way manufacturing is now generally directed by scientifically educated engineers. Will not this development probably lead the Captains of Industry to ask themselves whether the use of the methods of precision recommended by Taylor for studying the work of their employees, will not become in the near future as indispensable as chemical analysis is today for the purchase of mineral products? One can say to them, as to the workingman, Stop and think!

Right now, manufacturing is going through a serious crisis. During the last century, it attained a degree of expansion absolutely unforeseen, thanks to the help of the experimental sciences, mechanics, physics, and chemistry. During a few years it made more progress than had been made in all previous history. But this forward movement is beginning to slacken; the incessant struggle between capital and labor hinders further progress and menaces even the results already attained. To escape from this critical situation and to resume their forward march, manufacturers will have to apply themselves to the solution of the labor problem, and to this end they must call to their aid the economic and social sciences. The application of these sciences would seem to be as important for the development of public wealth in the future as that of the physical and natural sciences has been in the past. Now, according to Mr. Taylor, his system for the organization of labor would give an almost complete solution of the problems affecting the relations of capital and labor. There have never been either strikes or serious labor difficulties in the shops where this system is in operation. It would be worth the trouble to verify on the spot such a surprising fact. This would be an easy matter for manufacturers, as they are constantly sending their engineers abroad to study new types of machines: Why not send them also to study new methods of management? The workingmen, for their part, should commission the representatives of their unions to make a similar investigation.

The incessant struggle between capital and labor, which has reached an acute stage today, has two very distinct causes: first, the natural perversity of man which impels him to do the greatest possible harm to his neighbor, either by robbing him of his good fortune, or for the simple pleasure of evil doing; and second — and more happily — this ignorance of his own real interests.

The track walker who throws out a switch in order to wreck a train and to kill as many people as possible is a veritable vandal obeying the same instincts as the negro among the uncivilized natives of Africa, who slay for the pleasure of seeing the blood run. The speculator, who manipulates the stock market so as to ruin a laboring or agricultural district, the manufacturer who deteriorates the quality of his goods and cheats his customer, the business man who speculates with and loses the funds entrusted to him by his too confiding clients, have the same type of mind, and cause the same troubles, the same wrecks in society. From time immemorial the average morality of men has hardly varied. The fear of the police, religious sentiment, and the power of custom in civilized communities can temporarily curb these evil instincts; but as soon as these reins are relaxed, man reverts to the savage state. This always becomes apparent after a revolution, when the power of the police is for the time being suspended, and likewise in any country where authority falls into disrepute. We must resign ourselves to living with this tendency towards disorder; while trying to maintain the authority of the police, cost what it may.

But, in addition to this, the ignorance of man on the subject of his real interests is prodigious. Especially is this true in the case of the working man. Fortunately this ignorance can be corrected; for man is constantly increasing his knowledge. A thousand years ago, not a single manual laborer knew how to read. Today almost all of them read. But although they do not yet have the smallest knowledge of the economic sciences, we must not, however, despair of their capacity to learn. This will require earnest effort. Some day employers and workmen will surely succeed in thoroughly grasping certain truths that simply do not exist for them at the present time. It is impossible to realize the extent of this ignorance, unless one has actually come into close contact with it.

I have always treasured the remembrance of an incident in which I happened to play a part at the beginning of my engineering career, when I was in charge of the operation of the mines of the mineralogical district of Besançon. One day I received a petition signed by all the workmen of the mines of Ougnée (Jura). They appealed to me as the representative of the management, and asked my protection from the superintendent of the mine. This man had induced them to agree to accept a piece work contract for taking out the ore, in place of the old day labor, and had, they said, entirely deceived them, as the new arrangements were less advantageous than the old. In response to my inquiry, the superintendent of the mine said: " Send me at once this petition with your approval, and I shall be only too happy to act upon it. I had made a mistake in the calculations which served as a basis for the establishment of new rates, and

I am now paying my miners wages which are more than 15% higher than the old ones. I did not know how to return again to the former schedule, not daring to hope for such a favorable opportunity as this."

Before studying the science of economics, one must believe in its existence. Today every one believes in the physical sciences. If an inventor were to pretend to have discovered the means of retarding or hastening the march of the sun, every one would laugh at him — workmen as well as employers. But in the realm of economic facts, there are no absurdities that one may not advance, with the certainty of finding believers to accept them. People do not as yet suspect the existence of determinate relations between different economic facts; that is to say, the existence of what we call natural laws. In the moral and the economic world, these laws are complex and difficult to study. They depend upon a greater number of single factors than in the material world; yet, like them, they cannot be evaded. In both cases the efforts which have been made to transgress these laws have ignominiously failed. The rulers of the first Republic of France believed it possible to procure resources by creating paper money, the *assignats*, and giving it forced circulation, but as a consequence the amounts in paper money demanded for the smallest purchase constantly advanced until no one could get anything in exchange for this paper; the severest measures proved powerless to give it any value; credit is regulated by laws which are beyond the mere whim of the legislator. For the same reasons, the Republic of 1848 was not able with its national *ateliers* to give employment to all laborers; not even to those who wished to work; still less to the loafers. Neither will the equalization of all wages, advocated today by certain visionaries, ever be realized. This also is an impossibility.

The general diffusion of the belief in the existence of inevitable natural laws, that is, the belief in determinism, will constitute an enormous step in advance, even if these laws whose possible existence is admitted remain unfathomed. This belief in determinism leads one necessarily to consider in every case the possibility of attaining the desired end. On the other hand, in the absence of this belief, our efforts are squandered in vain endeavors to find the best means of accomplishing the desired end: federations of unions and of employers, political action, etc. Effort and money are spent lavishly, and society is overturned without accomplishing anything, whereas a few minutes of preliminary reflection would often have sufficed to turn one aside from an impracticable scheme.

When belief in determinism shall have become common with employers and workmen, half of the social problem will be solved. Then also, the ideas of Frederick Taylor will find many advocates.

Let us suppose for a moment that the belief in economic determinism has become general and let us try to unravel some of its laws. Here is one, for example, to begin with, of such extreme simplicity that you will say that it is too obvious to deserve more than a statement.

In civilized countries men have a great desire for happiness; they seek all the amenities of life, and are willing to make strenuous efforts to procure them.

Restraint is indispensable in civilized countries. Often the negroes of the African tribes are satisfied with primitive homes; they go without clothes and have no other ambition than to lead a vegetative existence in the sunshine, without bestirring themselves. In these countries the economic conditions are exceptional.

On the contrary, in civilized countries the desire to enjoy the pleasures of life, each day more numerous, to possess the good things in increasing degree, to make more money (for money makes it possible to procure in exchange all the coveted joys) is certainly the most powerful motive to force men into action. One is dumbfounded at the amount of labor accomplished by the husbandmen, the small proprietors doing their own work, when they are sure of not having to divide the reward of their labor with any one else. Here is a fundamental truth; an economic law. In spite of its simplicity and its obviousness, it is necessary to call attention to it, because of the consequences which it entails.

Here is one of the consequences which, in itself, constitutes a second law, not less fixed than the first but, however, less generally accepted. It is of paramount importance from the point of view of the labor problem.

The inhabitants of a given civilized country become twice as rich, each time they succeed in doubling their productivity because, on the average, each one then has twice as many useful or agreeable things to use.

This truth, this law, is so self-evident, that there should be no need to elucidate it. In a country where each inhabitant would produce all the materials necessary for his needs, no competition would be possible; the law would then apply equally to savage tribes and to civilized races. Formerly, it was so in France; the peasant produced on his land the grain necessary for his nourishment; he then ground it to make flour, and he himself baked the bread. He raised a pig also; he killed it, and salted it for his winter food. He cultivated hemp, spun the thread and wove his cloth; he also grew the wood and the straw necessary for the building of his thatched house. In increasing his production, as the use of farm machinery today makes possible for him, he has obtained a greater output for his labor. The sale of the excess of his production has permitted him to replace the hovel of his fathers, by a solid house of stone, of concrete and of slate. His establishment in this luxurious house will remain for him the greatest joy of his life, and compensate him for all future toil.

Outside of certain mountainous regions, still deprived of the means of easy communication, this old type of agricultural organization is rarely found in France. Almost everywhere a specialization of labor has come about, by which it is possible for every man to obtain greater returns for his effort. The peasant of Beauce prefers to grow corn; the peasant of Normandy to raise stock. Neither of them continues to manufacture cloth, because it can easily be purchased at a much lower cost in the large mills. This division of labor necessitates incessant exchanges on their part, to allow each one to accumulate all the varied things considered necessary to comfortable living. If, thanks to the specialization, our peasants and our spinners together succeed in producing today, twice as many useful things as in the past, they will each one of them be able to procure either directly or by exchange, twice as much as formerly; they will then have become twice as wealthy.

We must, however, make a restriction here. Where specialization occurs, it is not sufficient that an isolated individual double his production, to become twice as rich; his neighbors must also do the same, for otherwise there would be no one with whom to exchange the products of his labor, and his increased output would then be of no use to him. Here we find an essential condition of the law of the proportion between the increase of production and that of wealth.

In civilized countries, this difficulty never presents itself because of a well-recognized rule not to concentrate one's efforts on the production of articles of too limited use. One can pursue without hesitation the multiplication of things used for food, for the toilet, for construction, for the means of transportation, etc., and of all the raw materials necessary for these industries, such as coal, iron, cement, etc. There is practically no limit to their consumption.

The following is a very clear illustration of this fact. In the early days of railroading no one even suspected the magnitude of the possible ultimate development of traffic; this was excusable, for terms of comparison were lacking. Today, it would seem that the experience of the past ought to render it possible to make fairly definite calculations in this matter. And yet a few years ago, at the time of the organization of the Metropolitan Railway of Paris, every one, including the most able railway engineers, absolutely miscalculated the capacity of the Parisians for intra-mural travel. They figured that they had made more than adequate provision, both as to the size of the trains and the frequency of their running. No sooner was the first line put into operation, however, than they were forced to recognize the necessity of doubling the length of the trains. They have since multiplied the number of lines in service, yet, in spite of all their efforts, they have not succeeded in overcoming an incredible congestión at certain hours of the day. We often hear that an increase in production does not necessarily bring about an increase in consumption; that we must avoid exceeding the power of the consumer to absorb. In reality, as demonstrated by the example of the metropolitan railway, there is no limit to this power of absorption. At least in civilized countries, because there is no limit, either, to the desire for comforts and luxuries. It is necessary to proclaim this truth incessantly and to make the whole world acknowledge it.

As long as this truth fails to be recognized, the ideas of Frederick Taylor will fail to be appreciated at their full value, for their sole object is precisely to increase every man's power of production. Machinery, although very often used without such methods as will secure its proper output, has already produced enormous results. Within a century it has increased man's productive power almost tenfold, and hence, increased tenfold his wealth. Without making any further change in the machinery itself, the method proposed by Taylor makes it possible for each workman to double, and sometimes even to triple, his production and in consequence to double and to triple the general wealth.

Why is it that a law so important, a thorough understanding of which is so useful, should be so often misconstrued and contested? The explanation must be sought among the multiple errors of judgment among men. Instead of appealing to ordinary common sense, they either make long calculations, entirely misleading, or else they allow themselves to be guided by unreasoned opinions.

The first mistake arises from the use of money (which is now universal) for the payment of salaries, instead of the old method of paying in kind. Money only serves to satisfy our needs in so far as it makes it possible for us to obtain useful articles, by exchange. Today the sum of one franc represents about kilograms of bread, while at the time of the *assignats* 1 franc represented less than 30 grams of bread. For the same amount of money spent the actual bread obtained was a hundred times less then than it is now. Now, in most cases, the workmen consider only the amount of money that they receive in wages. I for example, they all were to succeed in doubling their production, without having their wages increased, they would believe themselves to be absolutely robbed, and would think that they had secured no benefit from the increase in their output. In reality, at the same nominal wages, they would have doubled their income, because, on account of the diminution of the price of things resulting from this extra output, they would be able, with the same wages, to buy twice the amount of useful things for themselves.

The fact, is however, that the actual dollars and cents received is almost always increased in proportion to the increase of individual production. Frederick Taylor, in his system of scientific management, proposes to increase the wages 33 to 100% for the workmen who succeed in doubling or in tripling their production.

This primary difficulty, concerning the use of money, is not fundamentally very serious, and it could be satisfactorily explained to the workmen with very little trouble.

We come now to an objection which is much more serious, because it does not result entirely from an error. When the daily output of the shops in a given trade is suddenly doubled by the introduction of new machines and new methods of work, the inevitable consequence is a disturbance in the market of the manufactured article; increase of consumption does not at once follow the sudden increase of production. Prices fluctuate, wages must be reduced or some of the workmen discharged, to avoid too great over-production. The discharged workmen, who are obliged to learn a new trade, as well as those retained sometimes with reduced wages, suffer obvious hardship. It is against this loss that the efforts of the labor unions are directed in a desire to limit the production of all of their members; it is against the same difficulty that the employers also league themselves in their trusts, when they impose a limit to the production of each of the allied shops.

Both the employer and the workman are laboring under a common misapprehension, but one that is easily understood. The reduction of prices is, however, not the result of overproduction, for the capacity for absorption of a civilized country is, as we have already indicated, almost infinite: the damage results simply from too sudden and too violent fluctuations in the rise and fall of production. Men, and associations of men, cannot suddenly change their conditions and their habits, any more than a violently hurled stone can be stopped or its course suddenly deflected, without producing shocks or serious accidents. A sudden change in an economic condition is destructive; the diminution of production, indeed even more than its increase. To understand this, it is sufficient to note the social upheavals brought about by decreases, however insignificant, in the production of food stuffs. Consumers suffer keenly from it, as have often, by reaction, the producers whose stores have been pillaged. This happened during our first Revolution, and can be seen still in France, on the very day on which I write these lines.

We see here an absolute law. In the same way, temporary suffering is bound to follow whenever new legislative measures are put too suddenly into execution, changing the regime of commerce or of industry: particularly is this true of any new tax or of a change in customs duties. If manufacturers and merchants, however, are too often the first to provoke these economic disturbances by unreasonable demands, it is because they cherish the hope, frequently mistaken, that the loss may all be borne by their competitors and neighbors. When they demand protection for their manufactured products, they too frequently make it their business at the same time to prevent the according of the same advantages to the articles they consume, whether they be raw or manufactured materials.

All the economic ills imputed to the increase of production are in reality occasioned solely by the undue haste with which the changes are accomplished. The damage would be practically negligible if the changes were made with extreme deliberation. It is therefore an absolute and a serious error, from the point of view of both the general and the individual welfare, to insist on opposing an increase in production. The only concern need be to properly regulate the speed with which the change is made in order to reduce the necessary losses, and, in the last analysis, to accept cheerfully an inevitable temporary inconvenience which is negligible in view of the positive advantages which come to all of us as a result of the increase of wealth. In the application of economic laws, sufficient time should always be given for their establishment on a solid foundation, whether they be labor legislation, customs duties, or whatsoever. Of all economic disturbances, these two are perhaps the most dangerous, because by their very nature, they can be made instantaneously. On the contrary, in the case of an improvement in methods of production, that is, of the development of better machines and the perfecting of methods of work, this inconvenience is generally greatly reduced, because, from their very nature, these improvements can only be made slowly. It often requires more than ten years to bring a new manufacturing process into successful use. How many times have an inventor's patents, though legally valid for a period of fifteen years, become public property before they have had any considerable practical application! This was the case, for example, with the Siemens-Martin process for the manufacture of steel.

It will be the same *a fortiori* with the application of the scientific methods of work advocated by Frederick Taylor. In the fifteen years since the first publication of these principles, the number of shops that have put the new methods into use is negligible; it will probably be another fifty years before they come into general use; their application therefore need occasion no apprehension.

Every progressive reform tending to increase production is free from serious danger because, on one hand, the managers have time to study the general trend and to adapt themselves to its final consummation, and on the other hand, the constant coming and going of workmen in the shops makes it unnecessary to discharge them so as to compensate for their increase in productivity. At most, it is enough to hire a smaller number of men day by day, if, at any given time, the consumption in an industry falls behind the production. Finally, the manufactured products which accumulate in the shops are not lost; the normal demand for them is so great that they disappear very rapidly;

in certain industries the plant itself is completely renewed every ten or fifteen years. By a progressive evolution, all of the necessary changes can thus be made without any serious damage or loss.

A last difficulty, really the most serious of all, arises from the question of the equitable division of the profits between the workmen and the employers, between the producers and consumers. One of the characteristics of civilized races is, as we have already said, the disappearance of the small proprietor living alone on his land, and producing all that he needs to live. Specialization and coöperation have increased the productive power of man enormously; the great factories, with their many workmen, their engineers, their selling agents, and their moneyed stockholders, have made it possible to reach a production per capita out of all proportion greater than the results obtained in the past by individual workers. It is impossible to recede from this new type of organization; we must accept then one of the inevitable inconveniences of the new conditions, the necessity for sharing the profits of the joint accomplishment. Each of the two parties wishes to have the lion's share and this greed at times surpasses every other with the employer, as well as with the workman; it prevents their giving proper attention to other considerations often far more important. The workman hesitates to increase his output, for fear of seeing his employer profit from it more than himself, and the employer, remembering the hard years, fears to raise the wages of his employees, even when the increase in their production makes it possible for him to do so. At the same time, the owner of the business for once in accord with his fellow workers, refuses to reduce his selling price, even when the increase of production diminishes his cost price. It is painful to him to contribute too directly to the enrichment of the consumer.

This question of the division of profits is the most serious element in the labor problem to-day. Employer and employee alike wish to secure greater happiness; each wishes to reap the greatest possible reward for his labor. Now, as we said in the beginning, there are two ways to increase one's personal riches.

either to seize the largest possible proportion of the profits resulting from the work done in common, or to produce more, while keeping the percentage of division constant. Human nature is so constituted that it attaches much more value to gains of the first kind than to those of the second, while they are, in fact, by far the less important of the two.

Let us take the industries where the capital is large, and of such a nature that its returns can reach a total equal to the pay of the workmen. In spite of the efforts of certain Utopians the workmen will never succeed in wresting from capital the full amount of the profits, unless all the shops could shut down from day to day; and production, and in consequence wealth in general, would dwindle to nothing. Perhaps they will succeed some day in taking half of the actual returns now received by capital. They will first have to become better informed; they must first learn to understand and discuss a cost price, and they must not allow themselves to be tossed about by fair words; doubtless they will wait long for this Golden Age to come. If this time ever arrives, they will then, in these exceptional industries, have increased their share of the profits more than 25%, but this increase will be much smaller in the very numerous industries where wages play a predominant part in the cost of manufacture. While this small gain on the part of the workman has been slowly wrested from his employer, industrial improvements and the increase of the individual production of the workmen will have perhaps increased tenfold again the wealth of every one of them. About this enormous gain they do not concern themselves: they do not even suspect its existence.

The most elementary common sense demands the abandonment of prejudices concerning these two ways of increasing individual wealth. Employer and employee, of course, must continue to defend their right to their proper share resulting from the work done in common, for from the day on which either one would cease to protect himself, he would be sure of being absolutely robbed by his co-partners. But for all that, the far more important consideration of the increase of production must not be forgotten. On this point the essential interests of the employer and of the workmen are identical, and it ought to be easy for them to coöperate.

They should do just what many producers and consumers are now doing who know how to work together for their common interests. For example, although in France manufacturers of steel and the engineers of the great metal working companies are in constant warfare with their customers, the railroad companies and although they do not easily agree on selling prices, on the terms of contracts, nor on any of the commercial questions where their interests are opposed: yet this does not prevent their recognizing that it is mutually profitable to improve the quality of steel and they meet together in technical conventions to discuss these questions. They willingly fraternize on a vantage ground where their interests are identical. Workmen and employers ought to do the same.

In a more or less distant future all these elementary truths will surely be generally accepted. When that day comes, workingmen will no longer start a strike because of the introduction of new machines into their shops; they will do so rather when their employers are too ignorant or too old-fashioned to increase their output per man as they ought to by the introduction of the most efficient machines and methods, in this way securing for themselves higher wages, not forgetting of course to demand proportionally a fair share of the profits for the work done in common.

The scientific management of our factories and industrial works proposed by Frederick Taylor is a realization of the essential ideas here suggested; it demands of the captains of industry that they apply their knowledge and experience to increasing the capacity for production of their workmen; and to the workmen it offers as a reward for their increased output a large increase in wages, to say nothing of the greater value given to money earned by the worker brought about through the reduction in the selling price of manufactured articles because of their lower cost price.

But to attain this end, the belief in economic determinism must first be made general, and the acceptance of the law must be general, that an increase in output means an increase in wealth. This is today the battle to be won. In the past the physical sciences have increased tenfold the riches of the world; in the future the economic sciences will perform again the same miracle.

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